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DEVELOPMENT OF A CURRICULUM TO MEET CHANGING MANPOWER NEEDS OF THE COMPUTER AND BUSINESS MACHINE INDUSTRIES; INTERIM DEVELOPMENTS. FINAL REPORT.

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This suggested curriculum guide represents the consensus of opinion by the representatives of seven schools comprising the Technical Education Consortium, with advice of industrial experts concerning the essential educational needs of the technicians they would employ. It will serve as a guide to schools planning to institute a program applicable to the business machine and computer industries and can be modified by the schools. A curriculum outline is presented for the four semesters. Course outlines include hours required, prerequisites, corequisites, course descriptions and objectives, major divisions, outlines of instruction, and texts and references for courses titled: (1) Electricity and Electronics, (2) Principles of Physics I, (3) Mathematics I, (4) Technical Graphics, (5) English Composition, (6) Electricity and Electronics II, (7) Introduction to Data Processing, (8) Mechanisms, (9) Principles of Physics II, (10) Mathematics II, (11) Digital Computer Fundamentals, (12) Electro-mechanical Components, (13) Control Systems, (14) Communications Skills, (15) Digital Computing Systems, (16) Input/Output Devices, (17) Storage Principles and Devices, and (18) Psychology and Human Relations. Included in the appendixes are sources of audio-visual materials, sample laboratory experiments, sample examinations, a bibliography, and a list of equipment needed in laboratories. (MM)

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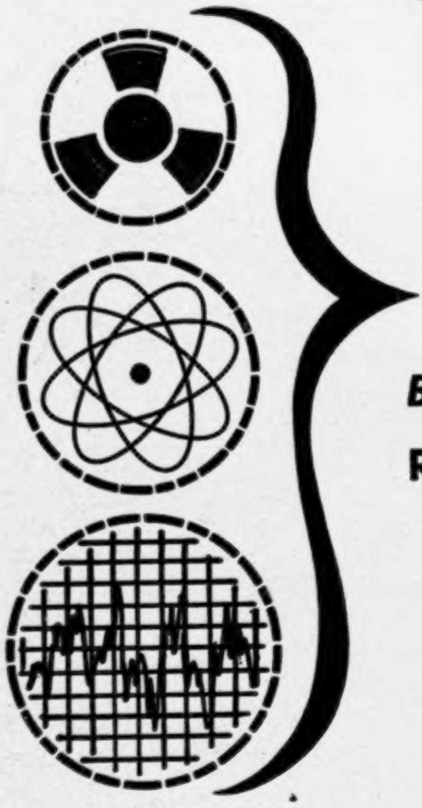

By
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Interim Developments
FINAL REPORT

DEVELOPMENT OF A CURRICULUM TO MEET CHANGING MANPOWER NEEDS OF THE COMPUTER AND BUSINESS MACHINE INDUSTRIES

Roland F. Lescarbeau, et al

The suggested curriculum reported herein was developed pursuant to a grant with the Office of Education, U. S. Department of Health, Education and Welfare. Contractors undertaking such projects under Government sponsorship are encouraged to express freely their professional judgment in the development of the project. Points of view or opinions stated do not, therefore, necessarily represent official Office of Education position or policy.

Pending approval of the final report of this project by the U. S. Department of Education, these materials are distributed at this time for examination and experimental use only, subject to controls established by the Technical Education Consortium, Inc., with headquarters at the Ward Technical Institute--University of Hartford, Hartford, Connecticut.

U. S. Department of
Health, Education and Welfare

Office of Education
Bureau of Research

This report represents a working curriculum for dissemination purposes. Schools using this data are requested to make comments and suggestions for final review of this study by summer of 1969.

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The completion of this suggested curriculum represents the thoughts of many industries and individuals not connected with the project. Financial support and equipment were generously contributed to help provide proper research. A special tribute is extended to the computer and research industries who whole-heartedly endorsed and aided in this project. Special acknowledgement is given to:

International Business Machines, Incorporated;
Honeywell, Incorporated;
Xerox, Incorporated; and
UNIVAC.

Other industries participating include:

Bell and Howell
The Burroughs Corporation
Dupont Nemours
General Electric Corporation
Eastman Kodak Company
National Cash Register Corporation
Olivetti Underwood Corporation
Victor Comptometer Corporation
Royal McBee Corporation
Bell Telephone Company
Monroe International
North American Aviation, Incorporated
American Research and Development Corporation
Bunker-Remo Corporation
Radio Corporation of America
Philco Corporation
Controlled Data Corporation
Texas Instruments, Incorporated
McDonnell Aircraft Corporation
International Telephone and Telegraph
Litton Industries
Raytheon Company
Recordak Company
Friden, Incorporated

In addition to the industries who indicated special interest in this project, BEMA, the service organization for the Business Equipment Manufacturers Association, was particularly helpful. Major publishers of scientific text books also provided assistance regarding the educational materials which were available and could be used until new texts were written. These companies will be found in the bibliography contained in this document.

FOREWORD

The "suggested curriculum" for Electromechanical Technology, oriented to the business machine and computer industries, developed in the following pages is the result of the combined thought and effort of many people.

The concept of a Consortium approach was the idea of Charles Bowen of IBM, who recognized that his company, like many others, needed technicians with uniform educational background who could be utilized equally well at any branch located throughout the World.

Other companies, recognizing the problem, agreed that if a uniform curriculum could be developed by a consortium of schools with individual philosophies, representing various geographical areas and already recognized as serving diverse technical needs, the resulting curriculum would provide a more compatible and uniform approach to industrial needs than could otherwise be achieved.

Six institutions, DeVry Institute, New York City Community College, Oregon Technical Institute, Southern Technical Institute, Dunwoody Industrial Institute and the Ward Technical Institute, representing public, propriatory, independent institutions and divisions of universities, were encouraged to participate in this endeavor. Ultimately they formed a non-profit corporation, the Technical Education Consortium, Inc., operating under the jurisdiction of the State of Connecticut. Subsequently Spring Garden Institute joined, becoming the seventh member.

To assure maximum useful content for the curriculum, industrial experts were asked to provide opinions about the essential educational needs of the technicians they would employ. Contributions of information by George Fisher of BEMA, George Hoffmeister of Honeywell, Daniel Zollo of UNIVAC, Clarence McNeil of IBM and Steven Crawford of Xerox, among others, were particularly helpful. Additional assistance regarding the hardware to teach applications was given by many industrialists, but particularly by Dura Sweeney and John Naden of IBM.

Although the "suggested curriculum" contained here is primarily oriented to application by the business machine and computer industries, the principles are universal in nature. During the development period, experience has already indicated that the electromechanical devices used in the computer and business equipment field are similar to those required for such occupations as aeronautics, automation and numeral control systems, and graduates from initial test programs have been widely sought by companies using such technicians.

Special acknowledgement should be given to those educators who themselves were not participants in the curriculum development, but who gave invaluable advice along the way. This is particularly true of the specialists from the U. S. Department of Education who kept the Consortium constantly alerted to studies and developments being made in this area of education, and who assisted by providing sound advice as the project was being developed.

Without such assistance from a wide range of interested parties, from government, industry and education, all recognizing the value of different approaches, but agreeing on common principles, this study could not have been prepared in its present form.

Douglas M. Fellows
Consortium Chairman

Suggested Two-Year Curriculum in Electromechanical Technology Oriented to the Computer and Business Machine Industries

PREFACE

The following curriculum approach to a two-year post-secondary program in Electromechanical Technology for the computer industry, represents the consensus of opinion by the representatives of the seven schools comprising the Technical Education Consortium.

Each of the member schools, after agreeing on the content requirements of such a program, developed a curriculum approach reflecting its geographical area, the type of students being served, and the type of industries employing its graduates. Based on these individual approaches, a composite was developed representing the common areas upon which all agreed.

It is expected this "suggested curriculum" will serve as a guide to schools planning to institute such a program. These schools will then modify this guide to reflect their educational philosophies as well as the type of students and industries they serve.

In addition to the administrative heads of member schools, the following deans and instructors, at one time or another during this development, have been instrumental in the preparation of the curriculum proposal.

Paul Meier, Oregon Technical Institute
Joseph Gershon, DeVry Institute of Technology
Arthur Baird, Dunwoody Industrial Institute
Arthur DelGiorno, New York City Community College
Yardy Williams, Southern Technical Institute
William Etsweiler, Jr., Spring Garden Institute
Louis Wertman, New York City Community College
George Crawford, Southern Technical Institute
Paul Chitwood, Oregon Technical Institute
Chester Gehman, Ward Technical Institute

All of the people involved in developing this program will be very happy to assist any school wishing to offer this program. Institutes they represent have opened their doors to all those needing help in instituting a similar program.

Roland F. Lescarbeau
Curriculum Chairman

TECHNICAL EDUCATION CONSORTIUM

GENERAL CONSIDERATIONS

The objective of the total curriculum recommended in this guide is to produce a competent electromechanical technician. The technician must be capable of working and communicating directly with engineers and production personnel in his specialized work, of satisfactorily performing work for his employer and of growing into positions of increased responsibility. In addition, the graduate technician should be an active, well-informed member of society.

A curriculum which will produce this type of graduate must be carefully designed. Each course must be planned to develop the student's knowledge and skills in that particular area and must be integrated into the curriculum. Each course contributes uniquely in the sequence of courses which is specially planned to progress toward the final objective of producing a competent technician. A close correlation between the courses and an interdisciplinary approach within each course will assure the depth of understanding required of electromechanical technicians.

The technical content of the curriculum is intended to supply a wide background in the diverse areas of applied electromechanical technology. A firm foundation in electricity, basic electronics and the fundamentals of mechanics is planned in the first year. The following semesters of work build directly on this background but introduce material from many subject areas, such as mechanisms, data storage and logic devices, input and output devices, and digital computing systems.

Graduates of this curriculum can expect to find employment in many areas of the electromechanical field. Each area may require somewhat different abilities and different specialized knowledge and skills for a successful career. Most of these differences will be learned by continued study on the job or in part-time study to master the details of a specific area. The following listing shows some of the major areas of job opportunities for electromechanical technicians, as described by employers:

1. "Customer engineering" or "Field engineering" in the data processing field
2. "Field engineering" for numerical control apparatus
3. Research technician
4. Quality control technician
5. Industrial control technician
6. Technical writer
7. Automation technician
8. Applications technician
9. Sales engineering
10. Teacher in industrial training program
11. Military and civil service opportunities
12. Technical representative
13. Space technology applications
14. Medical technology applications
15. Atomic energy applications

Highly skilled technicians must be capable of working closely with engineers and scientists and of supervising and coordinating the efforts of skilled craftsmen and maintenance men. These capabilities allow technicians to be effective members of the team whose work is to plan, assemble, install, calibrate, evaluate, operate and maintain computers and automated equipment.

Because electromechanical technicians are employed in varied and specialized situations, the adequately trained electromechanical technician must have attained certain abilities, scientific knowledge, and technical skills. These have been broadly defined as follows:

1. Facility with mathematics; ability to use algebra and trigonometry as tools in the development of ideas that make use of fundamental scientific and engineering principles; and an understanding of, though not necessarily facility with, higher mathematics through elements of analytical geometry and calculus.

2. Proficiency in the application of physical science principles, including the basic concepts and laws of physics that are pertinent to the individual's field of technology.

3. An understanding of the materials and processes commonly used in the technology.

4. An extensive knowledge of a field of specialization, with an understanding of the engineering and scientific activities that distinguish the technology of the field.

5. Communication skills that include the ability to interpret, analyze, and transmit facts and ideas graphically, orally, and in writing.

6. The ability to get along with people.

The electromechanical technician must blend all the foregoing abilities, knowledge, and skills as he performs several of the following general activities:

1. Applies knowledge of science and mathematics extensively in rendering direct technical assistance to scientists or engineers engaged in scientific research and experimentation.

2. Develops and plans modifications of new products and processes under the supervision of engineering personnel in research, design and development.

3. Plans and inspects the installation of complex equipment and control systems.

4. Advises, recommends, and implements procedures or programs for the maintenance and repair of complex equipment used in control systems.

5. Advises, plans, and estimates costs as a field representative of a manufacturer or distributor of technical equipment and/or products.

6. Assumes responsibility for performance or environmental tests of mechanical, hydraulic, pneumatic, electrical, or electronic components of systems and for the preparation of appropriate technical reports covering the tests.

7. Prepares or interprets engineering drawings and sketches.

8. Selects, compiles, and uses technical information from references such as engineering standards, handbooks, and technical digests.

9. Analyzes and interprets information obtained from precision measuring and recording instruments and makes evaluations upon which technical decisions are based.

10. Analyzes and diagnoses technical problems that involve independent decisions.

11. Deals with a variety of technical problems involving many factors and variables which require an understanding of several technical fields.

A two-year curriculum must concentrate on primary or fundamental needs if it is to prepare individuals for responsible technical positions in modern industry. It must be honestly pragmatic in its approach and must involve a high order of specialization. The curriculum suggested in this bulletin has been designed to provide maximum technical instruction in the time that is scheduled.

To those who are not familiar with this type of educational service (or with the goals and interests of students who elect it) the technical program often appears to be inordinately rigid and restrictive. Modifications may be necessary in individual institutions but the interdisciplinary philosophy of this curriculum should be maintained.

The specialized technical courses in electromechanical technology are laboratory-oriented. They provide application of the scientific principles concurrently being learned in the courses in physics and mathematics. For this reason, mathematics and science courses must be coordinated carefully with technical courses throughout the program. This coordination is accomplished by scheduling mathematics, science, and technical courses concurrently during the first two terms, a curriculum principle that will be illustrated at several points.

FACULTY

The effectiveness of the curriculum depends largely upon the competence and the enthusiasm of the teaching staff. The specialized nature of the curriculum requires that the teachers of technical subjects have special abilities based on proficiency in subject matter and industrial experience. It is important also that all members of the faculty understand the philosophy, goals, and unique requirements that characterize this area of education.

To be most effective, members of the faculty responsible for this program must have interests and capabilities which transcend their area of specialization. All of the faculty members should be reasonably well oriented in the requirements for study in electromechanical science and applications so that they may use appropriate field examples or subject matter as supporting material in the teaching of their respective courses. For example, if the communications courses are to be of maximum value, the teacher should be familiar with the communications problems and demands placed on electromechanical personnel. Also, the scientific principles taught in the courses of physics, mathematics, and measurements require that the instructors emphasize and illustrate how the principles are applied in electromechanical technology. It is absolutely necessary that teachers in electrical, electronics, mechanical and electromechanical courses be knowledgeable in both fields.

Thus, teachers of specialized technical subjects require advanced technical training. In the past, many such teachers have been recruited from the ranks of the engineering profession. Recent experience has shown that engineering technology graduates who have acquired suitable industrial experience and who have continued their education often become excellent teachers in this type of program. Persons with this background are more likely to understand the objectives and unique instructional requirements of technical education, and often bring to the program the enthusiasm and an appreciation of the values of technical education that are essential to success.

Since the programs for highly skilled technicians must consist of a series of well-integrated courses in order to attain the scope and depth of adequate training, careful consideration must be given to when and at what level a new concept is to be introduced. This may be accomplished through "team teaching" which requires the organization of a technical staff into a coordinated teaching unit.

STUDENT SELECTION AND SERVICES

The curriculum is designed for high school graduates who have particular abilities and interests. In general, students entering the program should have completed two high school courses in mathematics, including algebra and geometry, and one year of a physical science, preferably physics.

The equipment used in the electromechanical laboratory will vary tremendously. It will be determined by the type of computer and business machine sub-assemblies available to the school instituting the program. The physical layout of the laboratory will vary accordingly. A typical layout is provided in the Appendix. For specific details, it's suggested that those who are planning to start such a program should visit several schools already conducting a similar program. The schools in the Technical Education Consortium are happy to provide this service.

A recommended approach to developing laboratory work and equipping electromechanical laboratories is to determine what experiments are needed for each course and then to design these experiments as far as possible using standard components. This approach requires more time and effort on the part of the staff, but because the experimental equipment has been assembled to demonstrate some principle or to make a specific experimental determination with clarity and precision, it usually accomplishes the best teaching.

SCIENTIFIC AND TECHNICAL SOCIETIES

Scientific and technical societies are important sources for instructional materials and other potential opportunities for benefits to both staff and students. Such societies provide, in their publications and in their regularly programmed meetings, a continuing disclosure and discussion of new concepts, processes, techniques, and equipment in the science and related technologies. They are probably the greatest single device by which persons interested in a particular phase of science keep abreast of new developments. Information is presented in such a manner as to provide a "popularizing" and informative bridge between the creative theoretical scientists and the applied science practitioners, including the technicians, and usually are the first medium to announce and describe significant discoveries and applications of research in the field.

Some scientific and technical societies whose publications and services may be of interest to electromechanical technician instructors and students are:

American Institute of Aeronautics and Astronautics

American Radio Relay League, Inc.

Institute of Electrical and Electronics Engineers

Instrument Society of America

CURRICULUM CONTENT AND RELATIONSHIPS

Functional competence in a broad field such as electromechanical technology has at least three components around which a curriculum must be designed:

1. The program should prepare the graduate to enter industry with a minimum of in-plant training.
2. The broad technical training, together with a reasonable amount of experience, should enable the graduate to advance to positions of increasing responsibility.
3. The foundations provided by the training must be broad enough to allow the graduate to do further study within his field. This further study may consist of the reading of journals, new text materials, or enrolling in formal courses.

This curriculum has been developed to meet these requirements.

This electromechanical technology curriculum guide reflects three basic requirements; functional utility, units of instruction in specialized technical subjects, and provisions for the teaching of principles by application.

The sequence of courses in a two-year technical curriculum is as important as the content of the courses if the limited time available is to be used to full effectiveness. In general, the subject matter in the curriculum is carefully coordinated in groups of concurrent courses which are arranged to blend smoothly from one group of courses into the next, thus carrying the student to a deeper understanding in the many diverse areas of electromechanical technology.

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The laboratory hours suggested in the curriculum outline and in the course descriptions are not necessarily intended to be in a single session, but rather as total hours of laboratory per week to be scheduled in reasonable and effective increments.

In technical curriculums, it is desirable that specialized technical course work be introduced in the first semester. Deferring this introduction even for one semester imposes serious limitations on the effectiveness of the total curriculum. Several important advantages result from an early introduction of the technical specialty:

1. It helps to provide motivation.

2. It is possible to achieve greater depth of understanding in specialized subjects in the later stages of the two-year program.

3. The student sees immediate application of the principles he studies in the concurrent mathematics and physical science courses.

The course outlines in this guide are short and descriptive. The individual instructor will have to prepare complete courses of study and arrange his specific material in logical order before starting instruction.

The course outlines are intended as guides rather than as specific instructional plans to be covered in an inflexible order. It is expected that the principles outlined in these courses will be supplemented with industrial applications whenever relevant. Field trips add to the effectiveness of the instruction.

Outside study is a significant part of the student's total program. In this curriculum two hours of outside study time are suggested for each hour of scheduled class time.

It should be noted that no examinations have been scheduled in the outlines. It is clearly intended that time be available for examinations. Therefore, a 16-week semester is assumed, and the outlines are designed to cover a full 15 weeks.

Electromechanical Technology

Curriculum Outline

1st Semester	Class	Lab	Total Contact Hours
Electricity & Electronics I	3	6	9
Principles of Physics I	3	3	6
Mathematics I	4	0	4
Technical Graphics	1	3	4
English Composition	3	0	3
	14	12	26
2nd Semester			
Electricity & Electronics II	3	6	9
Introduction to Data Processing	2	0	2
Mechanisms	3	3	6
Principles of Physics II	3	3	6
Mathematics II	4	0	4
	15	12	27
3rd Semester			
Digital Computer Fundamentals	3	6	9
Electromechanical Components	3	3	6
Control Systems	3	3	6
Communications Skills	3	0	3
	12	12	24
4th Semester			
Digital Computing Systems	3	6	9
Input/Output Devices	3	3	6
Storage Principles & Devices	3	3	6
Psychology and Human Relations	3	0	3
	12	12	24

Course Title: Electricity and Electronics I

Hours Required: Class, 3 hours; laboratory, 6 hours

Prerequisites: None

Corequisites: Mathematics I, Principles of Physics I

Course Description and Objectives:

The objective of this course is to familiarize the student with the concepts of the items listed under the major divisions.

Major Divisions:

I. Voltage, Current and Resistance
II. Measuring Devices
III. Circuits
IV. Network Theorems
V. Magnetostatics
VI. Inductance
VII. Capacitance
VIII. Voltage Generators
IX. Complex Algebra Notation
X. AC Circuits
XI. Oscilloscopes
XII. Transformers

Outline of Instruction:

I. Voltage, Current and Resistance
    A. Units
    B. Ohm's law
    C. Factors affecting resistance of conductors
    D. Wire sizes and resistances
    E. Color code for resistors
    F. Non-linear resistors
    G. Power in DC circuits

II. Measuring Devices
    A. D'Arsonval movement
    B. Electrodynamometer movement
    C. Iron vane movement
    D. Ammeters
    E. Voltmeters
    F. Ohmmeters
    G. Bridges
    H. Hall-effect devices

III. Circuits
   A. Series and parallel circuits
   B. Voltage relationships
   C. Current relationships
   D. Resistance relationships
   E. Series-parallel combinations
   F. Kirchhoff's laws
   G. Mesh analysis

IV. Network Theorems
   A. Current and voltage sources
   B. Transformations, Δ-Y or Y-Δ
   C. Thevenin's theorem
   D. Norton's theorem
   E. Node equations

V. Magnetostatics
   A. Magnets and forces
   B. Electromagnetism
   C. Flux density

VI. Inductance
   A. Induced EMF
   B. Self-induction
   C. Mutual induction
   D. Inductors
   E. Transients in the RL circuit
   F. Time constant
   G. Saturated reactors

VII. Capacitance
   A. Capacitors
   B. Charging a capacitor
   C. Permittivity
   D. Capacitors in series and parallel
   E. E and I in the RC circuit
   F. Time constant
   G. Energy storage
   H. Dielectric strength

VIII. Voltage Generators
   A. DC and AC voltages
   B. Sine wave
   C. Maximum, effective, average and instantaneous values
   D. Frequency and phase
   E. Average power
   F. Power in inductive circuits
   G. Power in capacitive circuits

IX. Complex Algebra Notation
    A. J-operator or rectangular form
    B. Polar form
    C. Exponential form

X. AC Circuits
    A. Series
        1. R only in the circuit
        2. RC only in the circuit
        3. RL only in the circuit
        4. RLC in the circuit
        5. power in a series circuit
    B. Parallel
        1. R only in the circuit
        2. R and C in parallel
        3. R and L in parallel
        4. R, C and L in parallel
        5. power in parallel circuits
    C. Series-parallel
        1. admittance, conductance and susceptance
        2. analysis of circuits
        3. power in series-parallel circuits
        4. network theorems applied to AC
    D. Resonance
        1. series circuits
        2. parallel circuits
        3. effect of frequency variation
        4. effect of L or C variation
        5. Q: effect of high or low value

XI. Oscilloscopes
    A. Electron motion in an electrostatic field
    B. Electron motion in a magnetic field
    C. Functional units
    D. Voltage measurements
    E. Phase and frequency measurements
    F. Limitations

XII. Transformers
    A. Simple transformer
    B. Voltage and turn ratios
    C. Coupling coefficient
    D. Phasing
    E. Impedance ratios

Texts and References:

Cooke, Basic Mathematics for Electronics

Gillie, Electrical Principles of Electronics

Lurch, Electric Circuits

N. Y. Technical Institute, Basic Electricity, Programmed Learning

Romanowitz, Electrical Fundamentals

Course Title: Principles of Physics I

Hours Required: Class, 3 hours; laboratory, 3 hours

Prerequisites: None

Corequisites: Mathematics I

Course Description and Objectives:

This two-semester sequence will equip the electromechanical technician with an understanding of the principles governing the operation of equipment he will develop and maintain. A conceptual and unified approach is presented wherein the learner is expected to understand relationships rather than perform extensive calculations. A basic introduction to Newtonian mechanics.

Major Divisions:

I. Physics and Measurements
II. Vector Quantities
III. Systems of Forces
IV. Torque and Equilibrium
V. Linear Motion
VI. Force and Motion
VII. Work and Energy
VIII. Momentum
IX. Uniform Circular Motion and Gravitation
X. Rotational Motion
XI. Harmonic Motion
XII. Elastic Properties of Matter
XIII. Fluids at Rest
XIV. Fluids in Motion

Outline of Instruction:

I. Physics and Measurements
  A. The importance of physics
  B. Standards of length and mass
  C. Units of time
  D. The MKS system of units
  E. Units and their conversion
  F. Measurement of angles
  G. Force
  H. Weight and mass

II. Vector Quantities
   A. Displacement
   B. Vectors and scalars
   C. The graphical addition of vectors
   D. Velocity
   E. Frame of reference
   F. Rectangular components of a vector

III. Systems of Forces
   A. Force and motion
   B. Newton's third law
   C. Concurrent forces
   D. Equilibrium under concurrent forces
   E. Friction
   F. Kinetic friction
   G. The coefficient of static friction
   H. Friction of an inclined plane
   I. Reducing friction

IV. Torque and Equilibrium
   A. Torque
   B. Center of gravity
   C. Equilibrium
   D. The conditions for equilibrium
   E. Types of equilibrium

V. Linear Motion
   A. Types of motion
   B. Instantaneous velocity
   C. Acceleration
   D. Uniformly accelerated rectilinear motion

VI. Force and Motion
   A. Newton's first law of motion
   B. Inertia
   C. Newton's second law
   D. The newton
   E. Gravitational units of force
   F. Newton's third law of motion
   G. Application of Newton's second law
   H. Momentum and Newton's second law

VII. Work and Energy
   A. Work
   B. Units of work
   C. Power
   D. Energy and its conservation
   E. Potential and kinetic energy

- F. Transformation of potential and kinetic energy
- G. Simple machines
- H. Mechanical advantage and efficiency
- I. Rotating systems

VIII. Momentum
- A. Momentum and impulse
- B. The conversion of momentum
- C. Center of mass
- D. Collision phenomena
- E. Perfectly inelastic collisions

IX. Uniform Circular Motion and Gravitation
- A. Uniform circular motion
- B. Centripetal force
- C. Newton's law of universal gravitation
- D. Variations of weight with position
- E. Gravitational potential energy
- F. Applications of centripetal force

X. Rotational Motion
- A. Rotational velocity
- B. Angular acceleration
- C. Kinetic energy of rotation
- D. Moment of inertia
- E. Newton's laws for rotational motion
- F. Angular momentum

XI. Harmonic Motion
- A. Vibrations
- B. Simple harmonic motion
- C. The period of a simple harmonic motion
- D. Velocity in simple harmonic motion
- E. Force and energy relations

XII. Elastic Properties of Matter
- A. Molecular composition of matter
- B. Elasticity

XIII. Fluids at Rest
- A. Fluids and pressure
- B. Pascal's principle
- C. Archimedes' principle
- D. Density and specific gravity

XIV. Fluids in Motion
  A. Fluid friction
  B. Pressure in a moving field: Bernoulli's theorem

Texts and References:

Beiser, Basic Concepts of Physics

Beiser, Modern Technical Physics

Miller, College Physics

Smith & Cooper, Elements of Physics

Weber, Manning, White, College Physics

Lab: White and Manning, Experimental College Physics

Course Title: Mathematics I

Hours Required: Class, 4 hours; laboratory, 0 hours

Prerequisites: None

Course Description and Objectives:

A study which covers the concepts of basic mathematical functions; algebraic and graphic solutions of equations and systems of equations. The theory and use of the slide rule is stressed. Emphasis is placed on operational knowledge and the subject matter of trigonometry is investigated and its dependence on, and interrelationships with, algebra are utilized.

Major Divisions:

I. Fundamental Qualities of, and Operations with Numbers
II. Properties of, and Operations with Polynomials
III. Solution of, and Graphing of Linear Equations
IV. Solution of, and Graphing of Quadratic Equations
V. Exponents, Radicals and Logarithms
VI. Functions and Graphing
VII. Basic Trigonometric Functions and Relations
VIII. Complex Numbers and the J-Operator

Outline of Instruction:

I. Fundamental Qualities of, and Operations with Numbers
  A. Numbers, number symbols, order
  B. Fundamental operations
  C. Scientific notation
  D. Slide rule: multiplication and division

II. Properties of, and Operations with Polynomials
  A. Laws of exponents
  B. Grouping
  C. Operations on polynomials
  D. Factors and factoring

III. Solution of, and Graphing of Linear Equations
  A. Algebraic solution of a linear equation
  B. Rectangular coordinate system

    C. Slope-intercept form of a linear equation
    D. Graphing the linear equation

IV. Solution of, and Graphing of Quadratic Equations
    A. Algebraic solution
    B. Graphical solution

V. Exponents, Radicals and Logarithms
    A. Positive and negative exponents
    B. Laws of radicals
    C. Logarithms

VI. Functions and Graphing
    A. Maxima and minima
    B. Types of variation, writing equations
    C. Graphing
    D. Application problems
        1. linear
        2. logarithmic

VII. Basic Trigonometric Functions and Relations
    A. Angles
        1. definitions
        2. degrees
        3. radians
    B. Trigonometric functions defined
        1. limiting values
        2. signs
        3. relationships among functions
    C. Use of tables
    D. Use of slide rule

VIII. Complex Numbers and the J-Operator
    A. Fundamental operations
    B. Polar representation
    C. DeMoivra's theorem
    D. Roots of complex numbers

Texts and References:

Cooke, Basic Mathematics for Electronics

Fisher & Zieber, Integrated Algebra & Trigonometry

Nunz & Shaw, Electronic Math

Peterson, Intermediate Algebra for College Students

Rees & Sparks, *Algebra & Trigonometry*

Rice & Knight, *Technical Mathematics*

Washington, *Basic Technical Mathematics*

Course Title: Technical Graphics

Hours Required: Class, 1 hour; laboratory, 3 hours

Prerequisites: None

Course Description and Objectives:

This course is designed to instill a knowledge and understanding of the basic concepts of both mechanical and electrical drafting. Drafting is taught as a means of communication using the tools of orthographic and isometric projection. Careful attention is paid to proper representation.

The course is designed to develop skills in the mechanical and electrical area to permit the student to read and make simple drawings. Simplified methods, freehand sketching and the use of standard symbols will be stressed.

Throughout the course of study, emphasis will be placed on development of visualization. Wherever possible, the interdisciplinary area of electromechanical concepts will be introduced.

Major Divisions:

I. Sketching Techniques
II. Introduction to 2 View Orthographic Projection
III. Orthographic Projection
IV. Electrical and Electronic Drafting
V. Assembly Drawings
VI. Charts and Graphs

Outline of Instruction:

I. Sketching Techniques
    A. Purpose of course
    B. Isometric drawing
    C. Oblique projection
    D. Perspective projection

II. Introduction to 2 View Orthographic Projection
    A. Simplified drafting

- B. Symbols
    - 1. threads
    - 2. fasteners
    - 3. keys
    - 4. gears
    - 5. pins
    - 6. springs
- C. Use of standards tables

III. Orthographic Projection
- A. Use of tools
- B. 2-view
- C. 3-view
- D. Dimensioning
- E. Sectioning

IV. Electrical and Electronic Drafting
- A. Standard symbols
    - 1. use of templates
- B. Block diagrams
- C. Schematics
    - 1. elementary
    - 2. ladder
- D. Wiring diagrams
    - 1. tables (harness)
- E. Electromechanical components
- F. Chassis layouts

V. Assembly Drawings
- A. Purpose
- B. Standard procedures
- C. Bill of materials

VI. Charts and Graphs
- A. Purpose
- B. Standard practices
- C. Timing charts and cams

Texts and References:

Baer, C. J., Electrical and Electronic Drawing

Bishop, Electrical Drafting and Design

French and Vierck, Engineering Drawing

Giesecke, Mitchell and Spencer, Technical Drawing

Grant, Engineering Drawing, 2nd ed.

Kirchner and Stone, Electronic Drafting Workbook

Rasknodoff, Electronic Drafting and Design

Shiers, Electronic Drafting

Zazzora, Engineering Drawing

Visual Aids:

Models, film strips, films, overhead projector and transparencies, motor in parts, relay, limit switch, gears, cams, resistors, capacitors, transistors, diodes and scr.

Course Title: English Composition

Hours Required: Class, 3 hours; laboratory, 0 hours

Prerequisites: None

Course Description and Objectives:

The student's strength and weaknesses are analyzed through the use of diagnostic tests and exercises in writing, reading, and listening. Both technical and social skills are emphasized throughout the entire course.

Major Divisions:

I. Grammar and Spelling
II. Sentence Structure
III. Elimination of Errors in Sentence Structure
IV. Writing for Composition
V. Vocabulary Building
VI. Sentence Style
VII. Paragraph Technique
VIII. Business Correspondence

Outline of Instruction:

I. Grammar and Spelling
    A. Sentence sense
    B. Case
    C. Spelling
    D. Tense
    E. Mood

II. Sentence Structure
    A. Adjectives and adverbs
    B. Diagramming
    C. Sentence fragments, comma splice
    D. Faulty reference of pronouns

III. Elimination of Errors in Sentence Structure
    A. End punctuation; internal punctuation
    B. Non-restrictives; parenthetical elements
    C. Word punctuation; italics, capitals, apostrophe, hyphen

IV. Writing for Composition
    A. Quoted material
    B. The whole composition
    C. Effective paragraphs
    D. Paragraph development

V. Vocabulary Building
    A. Effective letters
    B. The whole composition; parallel structure
    C. Words and spelling
    D. Effective use of dictionary

VI. Sentence Style
    A. Effective sentence structure
    B. Jargon
    C. Parts of a sentence
    D. Form of a letter

VII. Paragraph Technique
    A. Making writing easy to read
    B. Effective paragraphs
    C. Paragraph development
    D. Effective letters and paragraphs

VIII. Business Correspondence
    A. Answers to inquiries, orders
    B. Claim letter and adjustment letters
    C. Credit letters
    D. Collection letters
    E. Sales letters
    F. Application letters

Texts and References:

American College Dictionary

Leggett, Mead and Charvet, Handbook for Writers

Shurter, Effective Letters in Business

Course Title: Electricity and Electronics II

Hours Required: Class, 3 hours; laboratory, 6 hours

Prerequisites: Electricity and Electronics I

Course Description and Objectives:

The objective of this course is to familiarize the student with the concepts of the items listed under the major divisions.

Major Divisions:

I. Balanced Polyphase Circuits
II. Power Supplies
III. Semiconductor Devices
IV. Electron Tube Characteristics
V. Amplifiers
VI. Feedback
VII. Oscillators
VIII. Pulse, Digital and Switching Circuits

Outline of Instruction:

I. Balanced Polyphase Circuits
  A. Two-phase
  B. Current and voltage relationships
  C. Three-phase
  D. Current and voltage relationships

II. Power Supplies
  A. Two terminal rectifiers
    1. vacuum diode characteristics
    2. gas diode characteristics
    3. semiconductor diode characteristics
  B. Half-wave rectifier
  C. Full-wave rectifier
  D. Bridge rectifier
  E. Three-phase rectification
  F. Voltage regulation

III. Semiconductor Devices
  A. Basic physics
  B. Ratings and limitations
  C. Graphical analysis

- D. Biasing methods
- E. Bias stability
- F. Field-effect transistor
- G. Other semiconductor devices

IV. Electron Tube Characteristics
- A. Triodes
- B. Tetrodes
- C. Pentodes
- D. Thyratrons
- E. Special Tubes

V. Amplifiers
- A. Triode
  1. load line analysis
  2. bias circuits
  3. equivalent circuit analysis
- B. Pentode
  1. characteristics
  2. operating potentials
  3. equivalent circuit analysis
- C. Transistor
  1. characteristics
  2. operating potentials
  3. equivalent circuit analysis
- D. Classes of operation
  1. class A, B, and C
  2. operating point
- E. Coupling
  1. direct
  2. RC
  3. transformer
  4. frequency response
  5. photoelectric
  6. decoupling
- F. Large signal
  1. single ended
  2. harmonic distortion
  3. power output
  4. push-pull

VI. Feedback
- A. Voltage feedback
- B. Gain
- C. Noise and distortion

- D. Input impedance
  - E. Output impedance
  - F. Current feedback
  - G. Oscillation
  - H. Selective feedback

VII. Oscillators
  - A. Phase shift oscillators
  - B. Feedback oscillators
  - C. Negative feedback
  - D. Bridge oscillators
  - E. Crystal oscillators

VIII. Pulse, Digital, and Switching Circuits
  - A. RC and RL circuits
  - B. Switches
  - C. Clippers, limiters, and clamps
  - D. Time base generators
  - E. Blocking oscillators
  - F. Multivibrators
  - G. Scalers and counters

Texts and References:

Alvarez, Fleckes, Introduction to Electronic Tubes and Semiconductors

Cutler, Active Networks, Vol. II

DeFrance, Electron Tubes and Semiconductors

Gillie, Pulse and Logic Circuits

N. Y. Technical Institute, Basic Electronics, Programmed Learning

N. Y. Technical Institute, Basic Transistors, Programmed Learning

Romanowitz, Electrical Fundamentals

Shrader, Electronic Communication, 2nd ed.

Course Title: Introduction to Data Processing

Hours Required: Class, 2 hours; laboratory, 0 hours

Prerequisites: None

Course Description and Objectives:

The intent of this course is to familiarize the student with data processing as a tool of society and to point out some of its benefits in the numerous areas of employment.

Major Divisions:

I. Introduction to Data Processing
II. Keypunching
III. Sorter: IBM Model 82
IV. Collator: IBM Model 85
V. Card Reproducing Machine: IBM Model 519
VI. Computer Operation
VII. The Console
VIII. Conversing with a Computer
IX. Problem Solving Using Symbolic Language
X. Problem Solving Using a Problem-Oriented Language

Outline of Instruction:

I. Introduction to Data Processing
  A. Manual methods
  B. Electromechanical methods
  C. Electronic data processing
  D. Recent developments in electronic data processing
  E. Uses and applications of the computer
  F. Capabilities and limitations

II. Keypunching
  A. Orientation: card code
  B. The keyboard: "alpha" and "numeric" shift
  C. The program-control card

III. Sorter: IBM Model 82
  A. The logic of sorting
  B. The controls of the sorter

IV. Collator: IBM Model 85
   A. Merging and selection logic
   B. Wiring the control panel

V. Card Reproducing Machine: IBM Model 519
   A. Gangpunching, in-line and offset
   B. Duplicating, in-line and offset
   C. Comparing
   D. Major-minor gangpunching

VI. Computer Operation
   A. Number systems
   B. Functional units
      1. input and output
      2. memory
      3. arithmetic-logic
      4. central processing unit-control

VII. The Console
   A. Associated equipment
   B. Demonstration problem

VIII. Conversing with a Computer
   A. Conversation difficulties
   B. Machine language
   C. Symbolic language (machine oriented)
   D. The assembly process (symbolic to machine language)
   E. The source and object deck
   F. Procedure-oriented languages (Autocoder, FORTRAN, COBOL, etc.)
   G. Automatic programming - the compiler

IX. Problem Solving Using Symbolic Language
   A. Flow charting
   B. Introduction to mnemonics (limited)
   C. Coding in symbolic language
   D. Execution of program from flow chart, to card punching, to computer execution, through debugging (correction) phase

X. Problem Solving Using a Problem-Oriented Language
   A. Flow charting
   B. Introduction to basic Autocoder (limited)
   C. Coding in Autocoder
   D. Execution of program from flow chart, to computer execution, through debugging (correction) phase

Texts and References:

Note: While no formal texts are assigned for this course, library assignments should be made which support lecture presentations. Also, excerpts from the following manuals should be available:

Manual of Instruction: 26 Keypunch, IBM Form #223-8319-9.

Manual of Instruction: 82 Sorter, IBM Form #

Manual of Instruction: 85 Collator, IBM Form #231-0001.

Manual of Instruction: 519 Document, Originating Machine, IBM Form #225-6320-1.

Reference Manual: 85 Collator, IBM Form #A24-1005-2.

Reference Manual: 519 Document, Originating Machine, IBM #A24-1017-1.

System Operation Reference Manual: 1401 DPS, IBM Form #A24-3067-1.

Colbert, Data Processing Concepts

Rath, Punch Card Data Processing

Course Title: Mechanisms

Hours Required: Class, 3 hours; laboratory, 3 hours

Prerequisites: Mathematics I, Principles of Physics I

Course Description and Objectives:

The study of fundamental concepts as found in basic mechanical and electromechanical mechanisms. These mechanisms will be studied in terms of their function, specifications and operating characteristics. Emphasis will be placed on the use of these mechanisms in integrated electromechanical systems as found in business machines and data processing equipment.

In the laboratory these mechanisms will be studied in an electromechanical system with respect to their input and output characteristics. Emphasis will be placed on methods of controlling and analyzing malfunctions. All laboratory projects will be designed and then constructed using breadboard techniques.

Major Divisions:

I. Fundamental Units
II. Levers and Linkages
III. Gears
IV. Transmission Components
V. Electric Controls

Outline of Instruction:

I. Fundamental Units
    A. Concepts of work
    B. Torque and torque measurement
    C. Velocity and acceleration
    D. Inertia (F=Ma)
    E. Horsepower
    F. Efficiency
    G. Timing charts - concepts and construction

II. Levers and Linkages
    A. Levers - analysis of load
    B. Linkages - 3 bar and 4 bar

- C. Velocity, acceleration and force transmission
- D. Laboratory projects
    1. intermittent feeding through linkages
    2. slider crank linkage mechanisms
    3. quick return linkage mechanisms

III. Gears

- A. Rack and spur gear - fundamentals and nomenclature
- B. Gear train ratios
- C. Torque and speed - ratio concepts
- D. Sources of power
- E. Power transmission
- F. Bevel gears
- G. Worm and worm wheel
- H. Spiroid
- I. Discussion of meaning of errors (actual vs. theoretical) - (fixed, cumulative and intermittent)
- J. Variable speed drives - epicyclic gear train, differential and integrator (friction drive)

IV. Transmission Components

- A. Belts and chains
- B. Shafting
- C. Keys, set screws, pins and splines
- D. Couplings
- E. Flexible shafts
- F. Clutches
- G. Brakes
- H. Cams
- I. Intermittent drives - geneva and ratchet
- J. Bearings

V. Electric Controls

- A. Magnetism
- B. Electromagnetism
- C. Solenoids
- D. Switches
- E. Relays - introduction

Texts and References:

Browning Transmission - Catalog

Beggs, Mechanisms

Berg, Theory and Application of Precision Mechanical Components

Faires and Keown, Mechanisms

Greenwood, Manual of Electromechanical Devices

Kepler, Basic Graphical Kinematics

Lent, Analysis and Design of Mechanisms

Penton Publishers, Electric Controls; Machine Design

Penton Publishers, Mechanical Drives; Machine Design

Phelan, Fundamentals of Mechanical Design

Pic Gear - Catalog

Wertman, Mechanisms Laboratory Manual

Winston, Mechanisms

Visual Aids:

Appropriate Pic Kit - Pic Gear, N. Y.
Linkage Kit - Techmation, Conn.
Switches and Relays

Course Title: Principles of Physics II

Hours Required: Class, 3 hours; laboratory, 3 hours

Prerequisites: Mathematics I, Principles of Physics I

Course Description and Objectives:

An introduction to the principles of heat, sound, light, electricity and magnetism and their simpler applications.

Major Divisions:

I. Temperature, Heat and Thermal Expansion
II. Kinetic Theory
III. Heat Transfer
IV. Wave Motion and Sound Sources
V. Light and Illumination
VI. Reflection, Refraction and Dispersion of Light
VII. Lenses and Optical Instruments
VIII. Electric Charges and Fields
IX. Electric Energy
X. Electromagnetism
XI. Relativity
XII. Electrons and the Bohr Atom
XIII. Conductors, Semiconductors, and Non-conductors

Outline of Instruction:

I. Temperature, Heat and Thermal Expansion
   A. Temperature scales
   B. Heat as a form of energy
   C. Heat units
   D. Expansion of solids
   E. The general gas law

II. Kinetic Theory
   A. Kinetic theory of gas pressure
   B. Dalton's law of partial pressures
   C. Work done by an expanding gas
   D. Diffusion

III. Heat Transfer
   A. Change of phase
   B. Conduction
   C. Convection
   D. Radiation

IV. Wave Motion and Sound Sources
   A. Transverse and longitudinal
   B. Wavelength, frequency, and velocity
   C. Representation of waves
   D. The reflection of waves
   E. Refraction of waves
   F. Standing waves
   G. The nature of sound
   H. Pitch, loudness, and quality
   I. Reflection of sound
   J. Refraction of sound
   K. Interference of sound waves
   L. Harmonics of a string
   M. Resonance, and the doppler effect

V. Light and Illumination
   A. The nature of light
   B. Standard sources and luminous flux
   C. Illuminance
   D. The photometer
   E. The velocity of light
   F. Frequency and wavelength

VI. Reflection, Refraction and Dispersion of Light
   A. Laws of reflection
   B. The plane mirror
   C. The concave spherical mirror
   D. The convex mirror
   E. Refraction

VII. Lenses and Optical Instruments
   A. Simple lenses
   B. Single lenses
   C. Combination of lenses

VIII. Electric Charges and Fields
   A. Electric and magnetic force
   B. Conductors and insulators
   C. Coulomb's law; conservation of charge
   D. Electric field; concept and models
   E. Potential difference
   F. Capacitance
   G. Inductance

IX. Electric Energy
    A. Electromotive force
    B. Joule's law
    C. Current and resistance
    D. Meters
    E. Motors and generators
    F. Back emf and back torque; eddy currents
    G. Transformers

X. Electromagnetism
    A. Magnetism and the magnetic field
    B. Induction, magnetic flux
    C. Magnetic domains and poles
    D. Magnetic force with respect to a moving charge
    E. Force on a current carrying conductor
    F. Force and torque on a complete loop

XI. Relativity
    A. Postulates
    B. Relativistic mass
    C. The mass of the electron
    D. General relativity

XII. Electrons and the Bohr Atom
    A. Cathode rays
    B. The Bohr atom
    C. Energy levels
    D. The atomic number

XIII. Conductors, Semiconductors and Non-conductors
    A. Types of conductors
    B. The nature of semiconductors
    C. The nature of insulators

Texts and References:

Beiser, Basic Concepts of Physics

Beiser, Modern Technical Physics

Miller, College Physics

Smith & Cooper, Elements of Physics

Weber, Manning & White, College Physics

Lab: White & Manning, Experimental College Physics

Course Title: Mathematics II

Hours Required: Class, 4 hours; laboratory, 0 hours

Prerequisites: Mathematics I

Course Description and Objectives:

The emphasis of this course is placed on analytic geometry with a study of lines and conic sections. A brief introduction of the concept of the limit of a function is presented. Integration of simple functions is covered. The course is solution oriented with applications in applied engineering.

Major Divisions:

I. Analytic Geometry
II. Variables, Functions and Limits
III. Differentiation and Applications
IV. Integration and Applications

Outline of Instruction:

I. Analytic Geometry
    A. Introduction to curves and equations
    B. The straight line
    C. The circle
    D. The parabola
    E. The ellipse
    F. The hyperbola

II. Variables, Functions, and Limits
    A. Variables and constants
    B. Continuous variation
    C. Limit of a variable
    D. Limiting value of a function
    E. Theorems of limits

III. Differentiation and Applications
    A. Increments
    B. Derivative of a function of one variable
    C. Differentiable functions
    D. General rule for differentiation
    E. Geometric intrepretation

IV. Integration and Applications
    A. Basic rules for integration
    B. Area calculation
    C. Mean value of a function

Texts and References:

Peterson, Calculus with Analytic Geometry

Steen and Ballou, Analytic Geometry

Course Title: Digital Computer Fundamentals

Hours Required: Class, 3 hours; laboratory, 6 hours

Prerequisites: Introduction to Data Processing

Course Description and Objectives:

The fundamentals of digital computers are studied from a non-mathematical approach. The student is first introduced to general purpose computing systems and the concept of a stored program computer.

The basic ideas of programming are presented to develop an understanding of the logical organization of a digital system.

The study of peripheral equipment touches upon card readers and punches, printers, tape and disk drives.

Major Divisions:

I. Introduction
II. Computer Programming
III. Computer Software
IV. Peripheral Equipment
V. Number Systems and Boolean Algebra
VI. Computer Components
VII. Computer Units
VIII. Computer Applications

Outline of Instruction:

I. Introduction
    A. Historical background
    B. Types of computers
        1. digital
        2. analog
    C. General block diagram

II. Computer Programming
    A. Typical computer problems
    B. Problem analysis and flow charts

- C. Instructions
- D. Subroutines
- E. Load routines

III. Computer Software
- A. Automatic programming
- B. Symbolic programming system
- C. Fortran
- D. Cobol

IV. Peripheral Equipment
- A. On-line and off-line operation
- B. Card and tape punches
- C. Magnetic tape drives
- D. Printers
- E. Card handling machines

V. Number Systems and Boolean Algebra
- A. Decimal
- B. Binary
- C. Octal
- D. Hexadecimal
- E. Binary coded decimal
- F. Binary arithmetic
- G. Basic ideas of Boolean algebra
- H. Boolean equations to logic diagrams
- I. Truth tables
- J. Karnaugh maps

VI. Computer Components
- A. Digital logic concepts
- B. Counters and decoders, coincidence detectors
- C. Storage registers
- D. Shift registers
- E. Adders and subtracters
- F. Timing generators

VII. Computer Units
- A. Input and output
- B. Memory systems
- C. Arithmetic unit
- D. Control logic

VIII. Computer Applications
- A. Applications in business and commerce
- B. Applications in applied science

C. Military applications
D. Industrial control by computer
E. Computers in education

Texts and References:

Bartee, Digital Computer Fundamentals

Burroughs Corp., Digital Computer Principles

Maley & Heilweil, Introduction to Digital Computers

Phister, Logical Design of Digital Computers

Scott, Analog and Digital Computer Techniques

Wegmer, Programming Language

Course Title: Electromechanical Components

Hours Required: Class, 3 hours; laboratory, 3 hours

Prerequisites: Mechanisms

Course Description and Objectives:

An in-depth study of mechanisms as they are specifically related to use in business machines and data processing machines applying the principles and concepts learned in the course in mechanisms.

Laboratory projects will give the student "hands on" knowledge of these mechanisms as individual units and as part of an overall electromechanical system.

Major Divisions:

I. Drives
II. Relays
III. Cam Operated Switches
IV. Electromechanical Clutches
V. Feeding Mechanisms
VI. Sensing - Reading Mechanisms
VII. Recording - Writing Mechanisms
VIII. Accumulating Mechanisms
IX. Control and Timing of Electromechanical Systems

Outline of Instruction:

I. Drives
    A. Motors
        1. DC
        2. single phase
        3. multiphase
    B. Comparitive characteristics
    C. Applications
    D. Maintenance

II. Relays
    A. Terminology and nomenclature
    B. Characteristics - electrical and mechanical
    C. Different types of relays
    D. Application
    E. Protection for arcing, noise and surge
    F. Maintenance

III. Cam Operated Switches
   - A. Characteristics - electrical and mechanical
   - B. Types of breakers
   - C. Application
   - D. Maintenance

IV. Electromechanical Clutches
   - A. Types of clutches
      1. positive
      2. friction
      3. magnetic
      4. magnetic particle
      5. overrunning
   - B. Characteristics
   - C. Application
   - D. Maintenance

V. Feeding Mechanisms
   - A. Basic feeding concepts
   - B. Parts feeding
   - C. Card feeding
   - D. Tape feeding
   - E. Loose paper feeding

VI. Sensing - Reading Mechanisms
   - A. Basic sensing concepts
   - B. Basic reading concepts
   - C. Card reading - static, dynamic, mechanical, optical
   - D. Paper tape reading - static, dynamic, mechanical, optical
   - E. Magnetic tape reading
   - F. Print reading - optical and magnetic

VII. Recording - Writing Mechanisms
   - A. Card punching
   - B. Tape punching
   - C. Card printing
   - D. Paper printing
   - E. Magnetic tape recording

VIII. Accumulating Mechanisms
   - A. Basic concepts of accumulating
   - B. Mechanical accumulators
   - C. Electrical accumulators
   - D. Electromechanical accumulators

IX. Control and Timing of Electromechanical Systems
    A. Clocks
    B. Timing devices
    C. Programmers
    D. Timing charts
    E. Flow charts
    F. Component and sub-assembly integration

Texts and References:

IBM Customer Engineering Manuals of Instruction:
    Functional Units
    1403 Printer
    1402 Card Read Punch
    519 Reproducer Punch
    1311 Disk Storage Drive

Bartee, Digital Computer Fundamentals

Berg, Theory and Application of Precision Mechanical Components

Faires and Keown, Mechanism

Greenwood, Manual of Electromechanical Devices

Lent, Analysis and Design of Mechanisms

Penton Publishers, Electric Controls; Machine Design

Penton Publishers, Electric Motors; Machine Design

Penton Publishers, Mechanical Drives; Machine Design

Phelan, Fundamentals of Mechanical Design

Wertman, Mechanisms Laboratory Manual

Course Title: Control Systems

Hours Required: Class, 3 hours; laboratory, 3 hours

Prerequisites: Mathematics II, Principles of Physics II, Electricity and Electronics II

Course Description and Objectives:

This course is designed to develop an understanding of basic systems and the devices used in these systems. In class the systems and devices will be analyzed and in the laboratory the student will connect, operate, adjust, and test the various devices individually and in simple systems.

Major Divisions:

I. Motor and Generator Characteristics
II. Motor Controls
III. Automatic Control Systems
IV. Sensing Devices (Transducers)
V. Measuring Devices
VI. Actuating Devices
VII. Control Devices
VIII. Applications

Outline of Instruction:

I. Motor and Generator Characteristics
    A. Shunt motors
    B. Series motors
    C. Compound motors
    D. Induction motors
    E. Split phase motors
    F. DC generators

II. Motor Controls
    A. Control-circuit functions
        1. acceleration
        2. control of speed
        3. stopping
        4. overload
        5. reversing

- B. Control devices
    - 1. resistors
    - 2. reactors
    - 3. autotransformers
    - 4. magnetic amplifiers
    - 5. SCRs and thyratrons

III. Automatic Control Systems
- A. Open loop
- B. Closed loop
- C. Control loop
- D. Time response
- E. Frequency response
- F. Stability
- G. Analog and digital

IV. Sensing Devices (Transducers)
- A. Motion
    - 1. linear
    - 2. angular
    - 3. speed of rotation
- B. Force
    - 1. pressure
    - 2. tension
    - 3. torque
- C. Temperature
    - 1. fluid
    - 2. resistive
    - 3. bimetallic
    - 4. thermocouple
- D. Radiation
    - 1. light
    - 2. x-ray
    - 3. radioactive

V. Measurement
- A. Electrical quantities
    - 1. voltage
    - 2. current
    - 3. resistance
    - 4. frequency
    - 5. inductance
    - 6. capacitance
    - 7. pulse rate

B. Counters
    1. mechanical
    2. electrical
    3. electronic
C. Time
    1. clock
    2. electronic
        a. time delay
        b. time interval

VI. Actuating Devices
A. Solenoids
    1. AC, DC
    2. pull, push, rotary
B. Relays
    1. electromechanical
    2. stepping
    3. latching
    4. meter
    5. thermal
    6. electronic
C. Synchros
    1. transmitters
    2. receivers
    3. differential
    4. control transformer
    5. circuits
D. Servomotors
    1. electric
    2. hydraulic
E. Fluid (gas or liquid)
    1. cylinder
    2. rotary
    3. diaphram
    4. valves
F. Miscellaneous devices
    1. saturable reactors
    2. magnetic amplifiers
    3. fluidic amplifiers
    4. variable transformers

VII. Control Devices
A. Pneumatic
B. Hydraulic
C. Electric

VIII. Applications*
  A. Analysis of servomechanisms
  B. Air conditioning system
  C. Speed control for paper making or tin plating of steel

* See References below for information.

Texts and References:

Bulliet, Servomechanisms

Considine, Process Control Instruments

Haines, Automatic Control of Heating and Air Conditioning

Holzbock, Automatic Control

Manifold, Automatic Control for Power and Process Industries

Marcus, Automatic Industrial Controls

Ruiter and Murphy, Basic Industrial Electronic Controls

*Siskind, Electrical Control Systems in Industry

Siskind, Electrical Machines

Tucker, Wills, Simplified Technique of Control System Engineering

*Zoss and Delahooke, Theory and Applications of Industrial Process Control

Course Title: Communication Skills

Hours Required: Class, 3 hours; laboratory, 0 hours

Prerequisites: English Composition

Course Description and Objectives:

A study of the fundamentals of public speaking including topic selection, organization, and effective speaking. The methodology of technical writing will be included and laboratory reports will be graded on their structure and grammar as well as the technical content.

Major Divisions:

I. Organizing a Speech
II. Presenting Speeches Effectively
III. Techniques of Technical Writing
IV. Transitions, Introductions, and Conclusions
V. Report Layout

Outline of Instruction:

I. Organizing a Speech
    A. Selecting a topic
    B. Library research
    C. Organizing material
    D. Organizing notes
    E. Arranging visual aids

II. Presenting Speeches Effectively
    A. Reading the speech
    B. Making a speech
    C. Conferences
    D. Graphic aids

III. Techniques of Technical Writing
    A. Definitions
    B. Descriptions
    C. Classification and partition
    D. Interpretation

IV. Transitions, Introductions, and Conclusions
    A. How to write a transition
    B. Where to put transitions
    C. Introductions
    D. Conclusions and summaries

V. Report Layout
  A. Introduction
  B. Elements of the formal report
  C. Relation of format and style
  D. Graphic aids

Texts and References:

Hays, Principles of Technical Writing

Weiss and McGrath, Technically Speaking

Selected reports from industrial organizations.

Course Title: Digital Computing Systems

Hours Required: Class, 3 hours; laboratory, 6 hours

Prerequisites: Digital Computer Fundamentals

Course Description and Objectives:

A study of the computer as a system: Its external data forms and functions; data input, program flow charts, instructions, programs.

The use of the digital computer and its peripheral equipment as a total system requires an understanding of man-to-computer communication, thus 1401 machine language, SPS, and AUTOCODER are presented in some depth. Other languages are considered.

The course will:

1. Provide the student with basic understanding and with practical applications of software and hardware data processing system concepts, and to introduce SPS, Autocoder, Fortran and other data processing languages.
2. Foster in the student a deeper understanding of the ways in which data processing systems can be utilized in modern scientific, commercial and industrial endeavors.
3. Promote an appreciation by the student of his place in the rapidly changing world of computers, automation and data processing systems.

Major Divisions:

I. The Nature and Challenge of Data Processing
II. Input Means and Methods
III. The Coding of Information: Machine Oriented Languages
IV. Miscellaneous Systems Operations
V. Procedure Oriented Languages
VI. A Specific Data Processing Application: Admissions/Registrar
VII. Other Hardware Systems
VIII. Data Processing Systems Using Other Techniques

Outline of Instruction:

- I. The Nature and Challenge of Data Processing
  - A. Basic ideas
  - B. Data processing: hardware systems
  - C. Data processing: software applications to the hardware
  - D. Sequential file processing

- II. Input Means and Methods
  - A. The presentation of information to the computer
  - B. Punched cards, layout and format
  - C. Punched tape, layout and format
  - D. Document readers
  - E. Tape, disk and drum as input media

- III. The Coding of Information: Machine Oriented Languages
  - A. Addressing core memory
  - B. Instructions versus data in core memory
  - C. Simple arithmetic instructions and data
  - D. Comparisons of coding: cards, punched tape, magnetic tape, disk, drum
  - E. Comparisons of accessing different media
  - F. Branching; loops and address modification
    - 1. flexibility of the branching idea
    - 2. applications and operations involving branching
    - 3. a practical case study: calculation of GPA
    - 4. computations for varying addresses
    - 5. counting and comparisons: loops
    - 6. modifying addresses via loops
    - 7. indexing and index registers
    - 8. a practical case study: table of square roots
  - G. Symbolic programming system
    - 1. flowcharting - the outlining of programs
    - 2. machine versus symbolic languages
    - 3. SPS language and the need for an SPS processor
    - 4. limitations of the simple SPS approach
    - 5. a practical case study: payroll

IV. Miscellaneous Systems Operations
  A. Editing and tabulating
  B. Carriage control
  C. Timing of input and output operations
  D. Calculations of the time required by a whole program
  E. Subroutines and utility programs
  F. A practical subroutine development: multiply

V. Procedure Oriented Languages
  A. The autocoder
    1. basic concepts
    2. constants, instructions and data
    3. arithmetic operations
    4. logic operations
    5. data moving operations
    6. miscellaneous: clear storage, set or clear word marks, halt, etc.
    7. input-output operations
  B. Autocoder practice problems
    1. "employee fund" program
    2. "charge account" program
    3. "payroll" program
  C. Advanced procedures
    1. program flowcharts and work flowcharts
    2. sequential data handling via magnetic tape
    3. reading and writing tape check procedure
    4. random access data handling via magnetic disks
    5. disk checking procedures
  D. FORTRAN language
    1. special needs for scientific programming languages
    2. what is a "more powerful" language or system?
    3. Fortran coding: control instructions
    4. Fortran coding: input-output instructions
    5. Fortran coding: indexing, counting and loops
    6. Fortran subroutines and their applications
    7. variations in Fortran for various data processing systems

E. COBOL and ALGOL languages
    1. special needs for business oriented languages
    2. forms and formats
    3. COBOL instructions
    4. example of program using COBOL
    5. ALGOL: description, applications and example

VI. Specific Data Processing Application: Admissions/Registrar
    A. The total problem
    B. Information flow and data formats
    C. Intermediate outputs
    D. Sequence of reports and other output data
    E. The team approach to coding the program
    F. Tests and checks

VII. Other Hardware Systems
    A. Comparative listings and how to read them
    B. Shared time and real time systems
    C. Computer systems
        1. various manufacturers

VIII. Data Processing Systems Using Other Techniques
    A. Automatic programmed tooling (APT)
    B. Remote terminals, their problems and applications
    C. Computer-controlled machines
    D. Programmed pipelines
    E. Space flights and computers

Texts and References:

Arnold, R. R., Hill, and Nichols, Introduction to Data Processing

Awad, Elias M., Automatic Data Processing

Bartee, Thomas C., Digital Computer Fundamentals

Benrey, Ronald M., Understanding Digital Computers

Burroughs Corporation, Digital Computer Principles

Flores, Ivan, Computer Design

Husky, Harry D., and Graniano A. Korn, Computer Handbook

Leeds, Herbert D., and Gerald M. Weinberg, Computer Programming Fundamentals

Litten Industries, Digital Computer Fundamentals

Mandl, Matthew, Fundamentals of Digital Computers

McCracken, Daniel D., A Guide to IBM 1401 Programming

Nashelsky, Louis, Digital Computer Theory

Salmon, Lawrence J., IBM Machine Operation and Wiring, 2nd Ed.

Saxon, J., and W. Steyer, Basic Principles of Data Processing

Swallow, Kenneth P. and W. T. Price, Elements of Computer Programming

Thatcher, C. M., and A. J. Capato, Digital Computer Programming: Logic and Language

Wegmer, Programming Language

Weinstein, Seymour M. and A. Keim, Fundamentals of Digital Computers

The following publications refer specifically to the IBM 1401 system. Comparable manuals relating to other systems should be utilized where applicable. IBM publications are available from IBM Data Processing Division, 112 E. Post Road, White Plains, N. Y. 10601

IBM FE Manual of Instruction, 1401 Data Processing System, form #225-6540-2.

IBM FE Pre-School, Part 2, 1401 Data Processing System, Student self-study course, form #R25-4926-1.

IBM FE Manual of Instruction, 1311 Disk Storage Drive, form #227-5703-1.

IBM FE Manual of Instruction, 1311 Disk Storage Drive, Model 4, form #225-3061-1.

IBM Systems Ref. Library, 1401 DPS Operator's Guide, form #A24-3144-2.

IBM Systems Ref. Library, Disk Storage Input-Output Instructions, form #A24-3070-2.

IBM Systems Ref. Library, System Operation Ref. Manual: 1401, #A24-3067.

IBM Systems Ref. Library, 1401 System Summary, form #A24-1401.

IBM Systems Ref. Library, 1401 Fortran Specs. & Op. Proc., form #C24-1455.

IBM Systems Ref. Library, 1401 SPS, Specs. & Op. Proc., form #C24-1480.

IBM Systems Ref. Library, 1401 Autocoder, 4K Op. Proc., form #

IBM Systems Ref. Library, Fortran II, Gen. Info. Manual, form #F28-8074.

IBM CE Manual of Instruction, 7330 Magnetic Tape Unit, form #223-6943.

IBM CE Ref. Manual, 7330 Magnetic Tape Unit, form #223-6967.

Course Title: Input/Output Devices

Hours Required: Class, 3 hours; laboratory, 3 hours

Prerequisites: Digital Computer Fundamentals, Electromagnetic Devices, Control Systems

Course Description and Objectives:

Input and output requirements of a computing system are discussed, introducing the student to types of devices in typical systems.

Individual equipments are presented with the object of stressing mechanical, electrical and logical principles of operation.

Major Divisions:

I. Introduction
II. Readers and Punches
III. Printers
IV. Tape and Disk Drives
V. Visual Displays
VI. Remote Terminals
VII. Magnetic Character and Optical Readers
VIII. Analog-Digital Converters

Outline of Instruction:

I. Introduction
    A. Types of input and output
    B. System block diagrams
    C. On-line and off-line operation

II. Readers and Punches
    A. Card readers
    B. Card punches
    C. Advantages and disadvantages of card systems
    D. Paper tape
    E. Photoelectric readers

III. Printers
    A. Mechanical printers
    B. On-the-fly printers
    C. Electrostatic printing

IV. Tape and Disk Drives
    A. Magnetic tape system characteristics
    B. Typical tape drive
    C. Disk drives
    D. Tape and disk recording techniques

V. Visual Displays
    A. Cathode ray tube displays
    B. Plotting devices

VI. Remote Terminals
    A. Inquiry stations
    B. Time sharing terminals

VII. Magnetic Character and Optical Readers

VIII. Analog-Digital Converters
    A. Analog to digital
    B. Digital to analog
    C. Encoders and decoders

Texts and References:

Bartee, Thomas C., Digital Computer Fundamentals

Benrey, Ronald M., Understanding Digital Computers

Burroughs Corp., Digital Computer Principles

Flores, Ivan, Computer Design

Husky, Harry D., and Graniano A. Korn, Computer Handbook

Litten Industries, Digital Computer Fundamentals

Maley & Heilweil, Introduction to Digital Computers

Mandl, Matthew, Fundamentals of Digital Computers

Nashelsky, Louis, Digital Computer Theory

Rath, Punch Card Data Processing, SRA

Weinstein, Seymour M. and A. Keim, Fundamentals of Digital Computers

Course Title: Storage Principles and Devices

Hours Required: Class, 3 hours; laboratory, 3 hours

Prerequisites: Digital Computer Fundamentals

Course Description and Objectives:

A study of storage as a basic need in computer systems including temporary, permanent, partial, and final. Fundamental information pertaining to addressing, access, synchronization and characteristics of the various media is included. The course will:

1. Introduce storage as a dominant need in computing systems.

2. Present the electronic and electromechanical devices that are used as storage devices.

3. Supplement theory with laboratory practice for reinforcement of theoretical concepts.

Major Divisions:

I. Introduction
II. Magnetic Fundamentals
III. Core Storage
IV. Thin-Film Memory
V. Magnetic Drum Storage
VI. Magnetic Disk Storage
VII. Magnetic Tape Storage
VIII. Card Random Access Memory
IX. Read Only Memories
X. Tunnel-Diode Memory
XI. Electronic Storage
XII. Mechanical and Electromechanical Storage
XIII. Electrostatic Storage Devices

Outline of Instruction:

I. Introduction
    A. Reasons for storage of information in the computer
    B. Concepts and nomenclature
        1. internal versus external
        2. binary loading (review)
        3. fixed and variable word lengths
        4. glossary of terms

II. Magnetic Fundamentals
    A. BH loop
    B. Magnetic equations
    C. Energy storage in the field
    D. Digital recording techniques
        1. return-to-zero methods
        2. non-return-to-zero methods

III. Core Storage
    A. Core magnetics
    B. Two dimensional array
    C. Three dimensional array
    D. Core storage economics
        1. access speed
        2. cost
        3. volume versus storage capacity

IV. Thin-Film Memory
    A. Physical layout
    B. Economics
        1. access speed
        2. cost
        3. volume versus storage capacity

V. Magnetic Drum Storage
    A. Physical layout
    B. Read-write heads
    C. Reading-writing
    D. Parallel operation
    E. Serial operation
    F. Economics
        1. access speed
        2. cost
        3. volume versus storage capacity

VI. Magnetic Disk Storage
    A. Physical layout
    B. Read-write heads
    C. Reading-writing and addressing
    D. Economics
        1. access speed
        2. cost
        3. volume versus storage capacity

VII. Magnetic Tape Storage
   A. Physical properties
   B. Transport mechanisms
   C. Read-write heads
   D. Reading-writing and addressing
   E. Economics
      1. access speed
      2. cost
      3. volume versus storage capacity

VIII. Magnetic Card Random Access Memory
   A. Card layout
   B. Read-write heads
   C. Reading-writing

IX. Read-Only Memories
   A. Physical layout
   B. Storing information
   C. Reading from memory

X. Tunnel-Diode Memory
   A. Characteristics
   B. Binary operation
   C. Memory

XI. Electronic Storage
   A. Bi-stable system
   B. Saturated versus non-saturated operation
   C. Triggering methods
   D. Applications
   E. Delay lines

XII. Mechanical and Electromechanical Storage
   A. Relay systems
   B. Stepping relay configurations
   C. Electromechanical storage devices
   D. Cams

XIII. Electrostatic Storage Devices
   A. Capacitive storage
      1. read-in and read-out characteristics
   B. CRT storage
      1. read-in and read-out characteristics

Texts and References:

Bartee, Thomas C., Digital Computer Fundamentals

Burroughs Corp., Digital Computer Principles

Flores, Ivan, Computer Design

Huskey, Harry D., Computer Handbook

Meyerhoff, Albert J., Ed. Digital Applications of Magnetic Devices

Nashelsky, Louis, Digital Computer Theory

Olsen, E., Applied Magnetism

Renewich, Digital Storage Systems

Thin Films, American Society for Metals

IBM Systems Ref. Library, 7330 Magnetic Tape Unit, Principles of Operation, form #A22-6589.

IBM Systems Ref. Library, 1311 Disk Storage Drive, Operating Principles, form #A26-5991.

IBM CE Manual of Instruction, 7330 Magnetic Tape Unit, form #223-6943-3.

IBM CE Manual of Instruction, 1311 Disk Storage Drive, Model 4, form #223-3061.

IBM CE Reference Manual, 7330 Magnetic Tape Unit, form #223-6967.

IBM CE Maintenance Manual, 1311 Disk Storage Drive, Model 4, form #227-5649.

Course Title: Psychology and Human Relations

Hours Required: Class, 3 hours; laboratory, 0 hours

Prerequisites: None

Course Description and Objectives:

Planned for the development of a better understanding of the human mechanism -- its motivation and learning ability as related to the interpersonal relations on the job. Employee selection, intelligence and aptitude tests, supervision, industrial conflict, and job satisfaction are considered. Attention is given to personal and group dynamics so that the student may learn to apply the principles of mental hygiene to his adjustment problems as a worker and as a member of society. Instruction is focused upon the practical applications of the principles guiding human behavior rather than their physiological origin or historical significance.

Major Divisions:

I. A Practical Science
II. Basic Psychological Principles
III. Problems of Adjustment
IV. Vocational Industrial Problems
V. Factors of Supervision
VI. Communications in Industry
VII. Industrial Conflict

Outline of Instruction:

I. A Practical Science
  A. Orientation to subject: posing and solving problems from life situations
  B. The scientific method
    1. awareness of problems
    2. collection of data
    3. hypothesis
    4. testing hypothesis
    5. confirmation or refutation

II. Basic Psychological Principles
  A. Motivation
    1. nature and classification of motives
    2. importance in understanding, predicting and controlling human behavior

        3. application to advertising, business and industry
    B. Emotions and feelings
        1. origin, function and physical aspects
        2. understanding and controlling
    C. Frustration
        1. causes
        2. various reactions to frustration
        3. application to industrial problems

III. Problems of Adjustment
    A. Abnormal reaction patterns
        1. dynamics of mental and emotional disorders
        2. chief classifications of disorders
        3. principles of general semantics and relevance to understanding of abnormal reactions
    B. Mental hygiene
        1. kinds of therapy and their rationale
        2. exploration of the concept of mental health
        3. achieving and maintaining mental health

IV. Vocational Industrial Problems
    A. Vocational problems: vocational choice
        1. factors in vocational choice: interests, attitudes, aptitudes, social abilities
        2. getting the job
    B. Vocational problems: on the job
        1. success on the job: job satisfaction
        2. promotion on the job: efficient study habits, effective thinking, intersocial problems

V. Factors of Supervision
    A. Employee selection
        1. theory and art of interviewing
        2. use of testing in industry
    B. Employee evaluation
        1. meaning and use of ratings, job evaluations, job analysis and description
        2. motion study and incentives in industry
    C. Employee leadership
        1. group dynamics in industry
        2. factors in leadership, discipline and morale
        3. training methods

VI. Communications in Industry
    A. Requirements in industrial communications
    B. Factors in evaluation
    C. Influence on morale

VII. Industrial Conflict
    A. Formation and perpetuation of attitudes and beliefs
    B. Factors of social conflict
    C. Psychology of unionism
    D. Psychology of organized conflict as exemplified in strikes and lockouts

Texts and References:

American Academy of Political and Social Sciences, "Automation," in Annals, March 1962.

Beach and Clark, Psychology in Business

Bellows, Psychology of Personnel In Business and Industry

Blum, Industrial Psychology and Its Social Foundations, rev. ed.

Blum, Readings in Experimental Industrial Psychology

Calhoon, Noland, and Whitehall, Cases on Human Relations in Management

Dubin, The World of Work--Industrial Society and Human Relations

Ghiselli and Brown, Personnel and Industrial Psychology

Hepner, Psychology Applied to Life and Work

Maier, Principles of Human Relations: Applications to Management

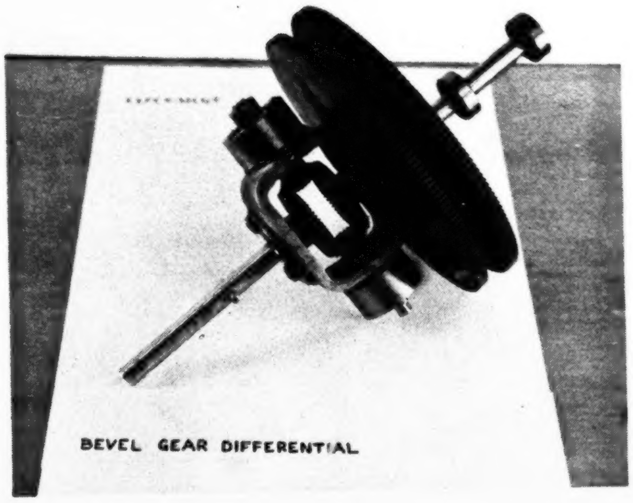
Maier, Psychology in Industry, 2nd ed.

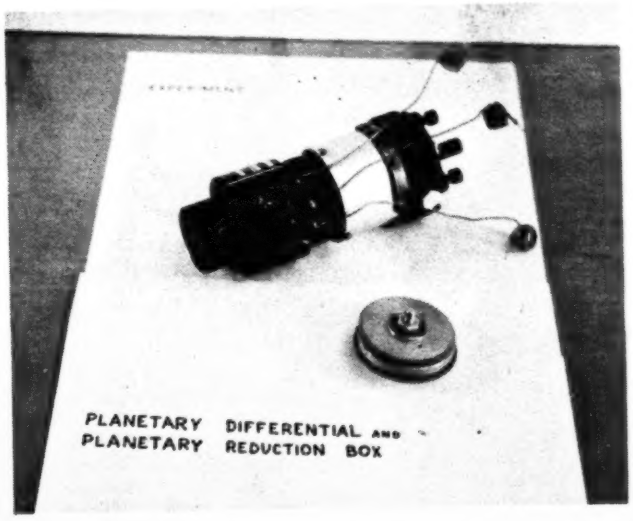
Ryan and Smith, Principles of Industrial Psychology

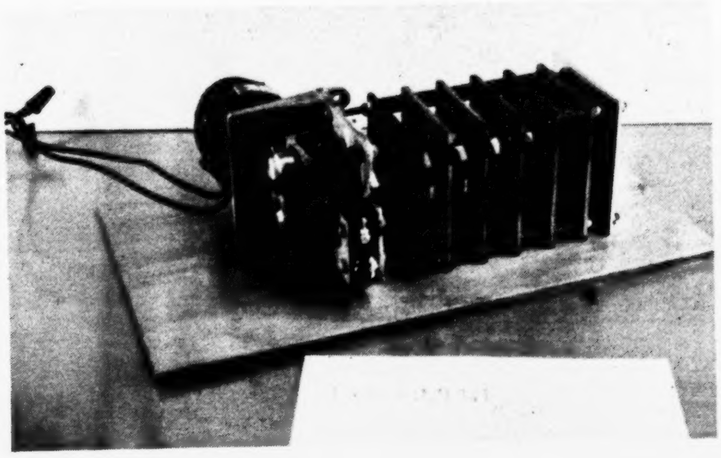
Smith, Psychology of Industrial Behavior

Stagner, The Psychology of Industrial Conflict

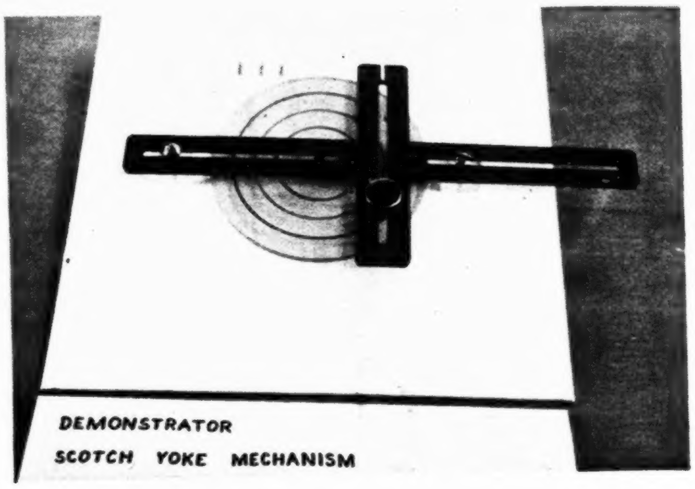
SAMPLE DEMONSTRATIONS AND LABORATORY DEVICES


BEVEL GEAR DIFFERENTIAL

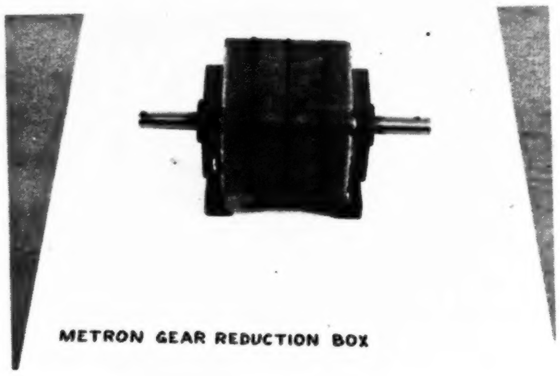

PLANETARY DIFFERENTIAL AND
PLANETARY REDUCTION BOX



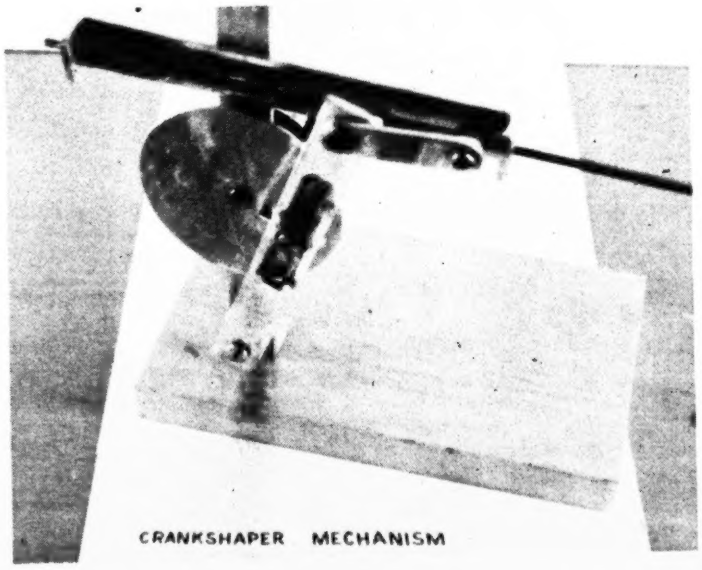
400Hz SYNCHRO DEMO.



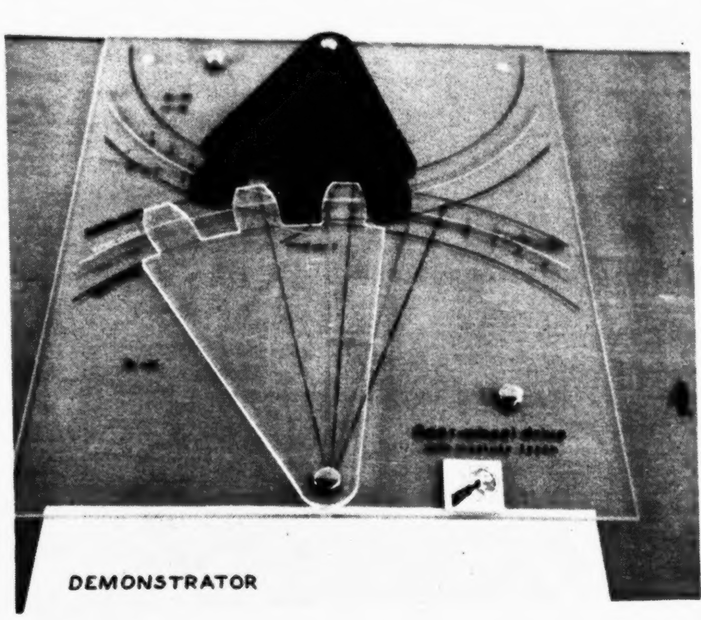
DEMONSTRATOR
SCOTCH YOKE MECHANISM



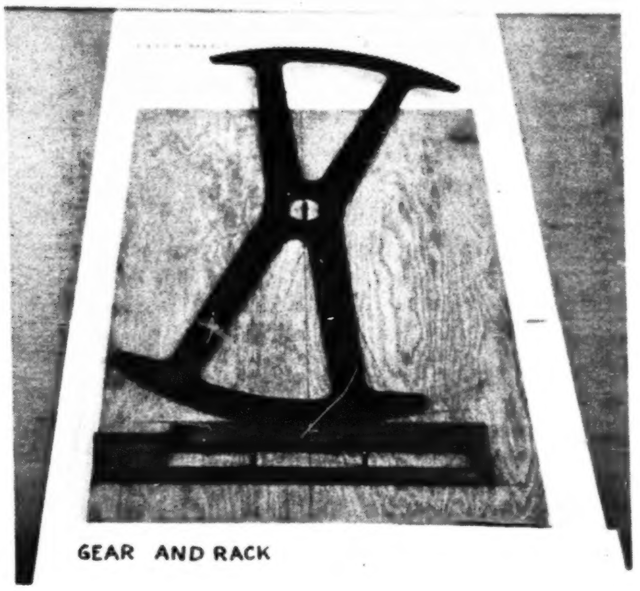
METRON GEAR REDUCTION BOX



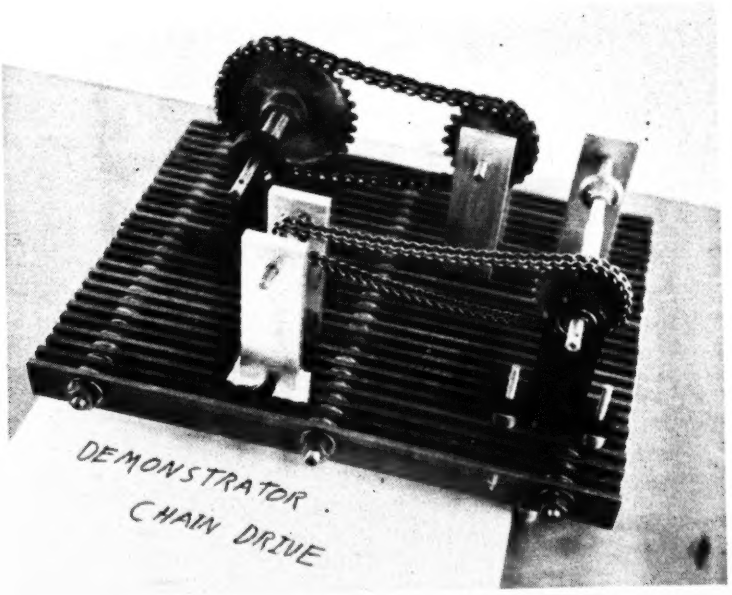
CRANKSHAPER MECHANISM



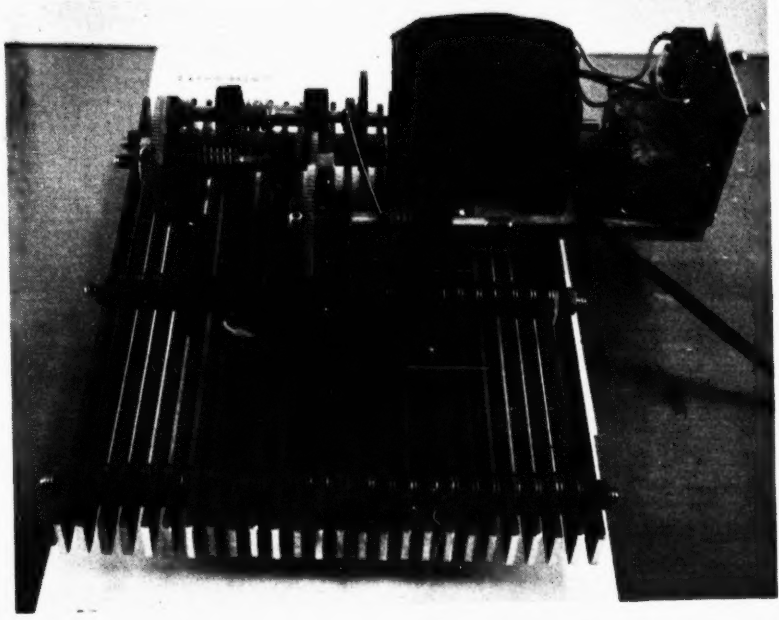
DEMONSTRATOR



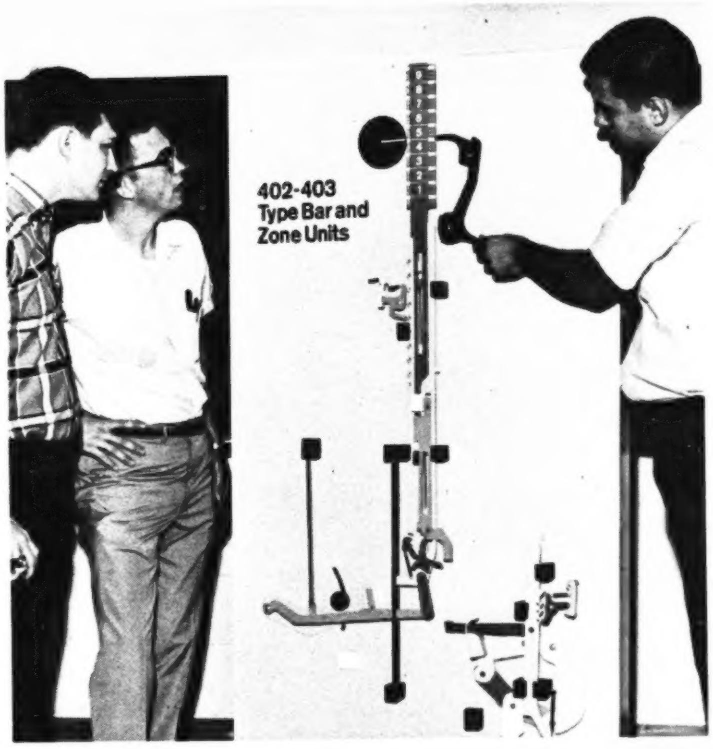
GEAR AND RACK

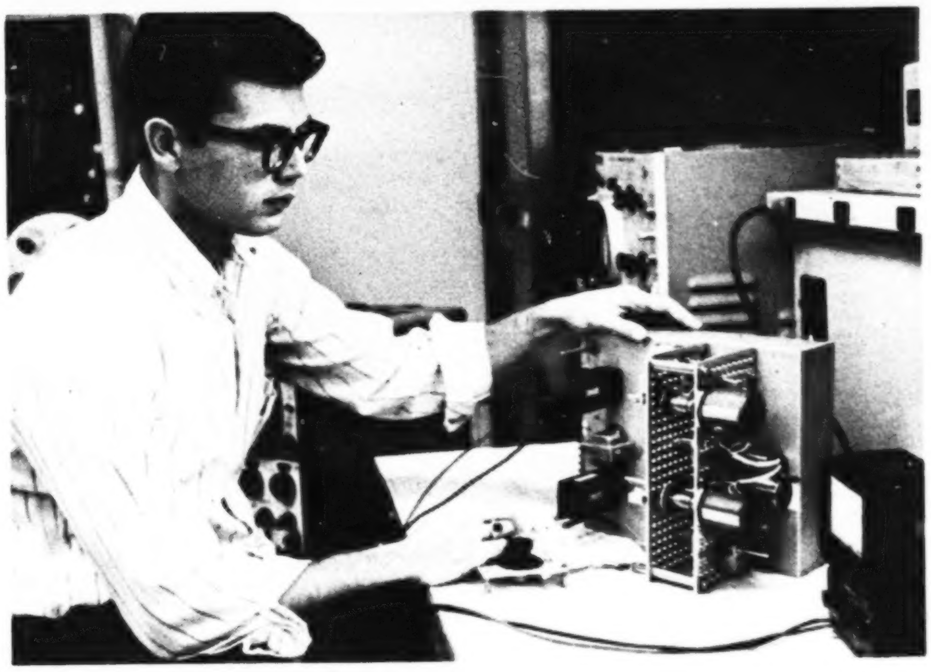


DEMONSTRATOR
CHAIN DRIVE



TYPICAL LABORATORY VIEWS





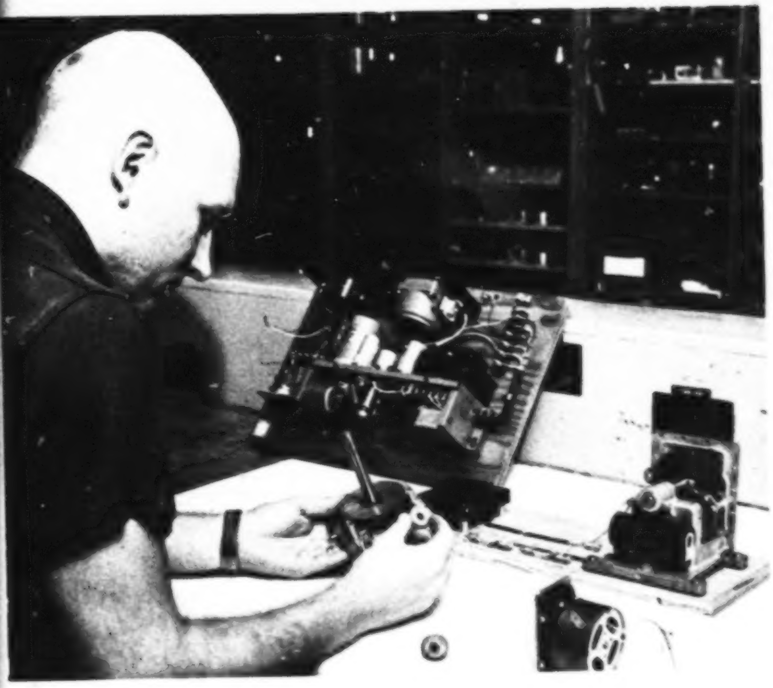
A typical training aid (top left) provided by IBM.

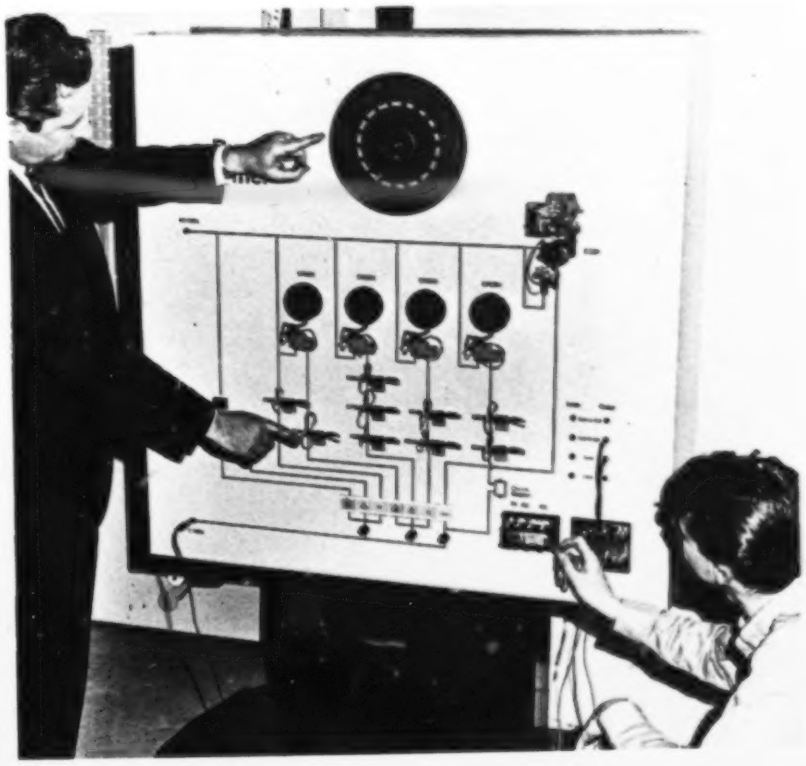
Top right: Basic principles are taught on sub assemblies.

Left: Trouble shooting on a 1401 computer system.

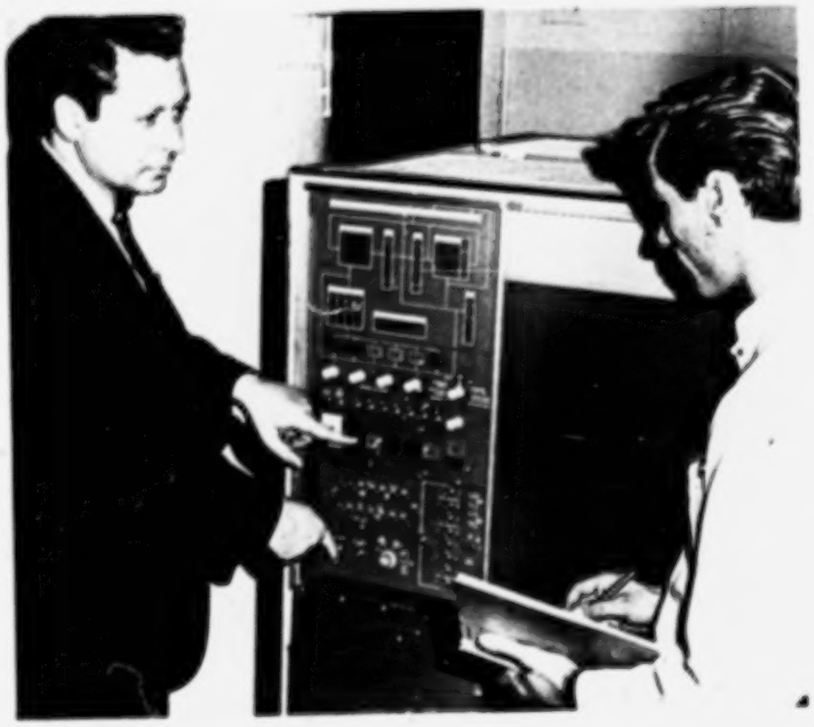
Below left: A laboratory model, demonstrates various methods of mechanically transferring motion.

Checking a punched tape computer input device, below.





Individual or small group instruction in the laboratory is the most effective method of teaching basic mechanisms, computer principles and input-output devices.



330 345 0
Punch Clutch
240

Top left: A student is taught operation of a typical computer.

Large mock-ups (top right) are used to demonstrate mechanical principles.

Above: A graduate applies his knowledge as a customer engineer.

The principles of computers (center right) are taught on small laboratory models.

Right: The student prepares a program on a punch card.

AUDIOVISUAL MATERIALS AND REFERENCES

1. Some Selected Sources of Audiovisual Materials:

Addison-Wesley Publishing Co.
Department EB201
Reading, Massachusetts 01867

California Test Bureau
206 Bridge Street
New Cumberland, Pa. 17070

Central Scientific Company
1700 Irving Park Road
Chicago, Illinois 60613

Coronet Instructional Films
65 E. South Water Street
Chicago, Illinois 60601

Doubleday and Company
Garden City
New York 11530

George Vincent McMahon
Electronic Engineering
Research & Development Labs
381 West 7th Street
San Pedro, California 90731

Encyclopaedia Britannica Inc.
425 North Michigan Avenue
Chicago, Illinois 60611

Ginn & Company
717 Miami Circle N. E.
Atlanta, Georgia 30324

Graflex, Inc.
Programmed Learning Dept.
P. O. Box 101
Rochester, New York 14061

Harcourt, Brace & World, Inc.
Dept. of Programmed Instruction
757 Third Avenue
New York, New York 10017

Inrad
P. O. Box 4455
Lubbock, Texas 79409

Lyons and Carnaban
407 East 25th Street
Chicago, Illinois 60616

McGraw-Hill Book Co., Inc.
350 West 42nd Street
New York, New York 10036

The Macmillan Company
60 Fifth Avenue
New York, New York 10011

Prentice-Hall, Inc.
Englewood Cliffs
New Jersey 07632

The Psychological Corp.
304 East 45th Street
New York, New York 10017

J. Ravin Publications
4215 Calevo Drive
LeMesa, California 92041

Science Research Associates, Inc.
259 East Erie Street
Chicago, Illinois 60611

Tarmac Audio Visual Co.
71 North Market
Asheville, North Carolina 28801

Teaching Materials Corp.
575 Lexington Avenue
New York, New York 10022

Training Systems, Inc.
12248 Santa Monica Boulevard
Los Angeles, California 90025

Tor Education, Inc.
55 Fifth Avenue
New York, New York 10003

Universal Electronics
Labs Corp.
510 Hudson Street
Hackensack, New Jersey
07601

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Sample Experiment (Mechanisms)

CLUTCHES AND ELECTROMAGNETS

MATERIAL REQUIRED

IBM Customer Engineering Manuals of Instruction:
Functional Units,
Reproducing Punches.
Variable output power supply.
Various assemblies to be obtained
from the instructor as needed.

DISCUSSION

The assemblies that are to be examined in this laboratory exercise perform specific functions in several types of business machines. The student should limit his investigations at this time primarily to the clutch action and how it is affected by the normal and energized states of the controlling electromagnet, or to the particular function of the electromagnet, as the case may be. The actual function of each unit as a whole will be studied in detail in later laboratory exercises.

PROCEDURE

PART I

Obtain the mock-up labeled "Punch Clutch" from the instructor. Examine it carefully, relating it to the illustration in the text. Locate the following parts, placing a check mark on the list after each item as the part is identified.

Clutch magnet and armature,
Disc representing the drive pulley,
Drive pulley sleeve,
Clutch sleeve,
Clutch spring,
Spring collar,
Clutch detent,
Detent latch.

1. What kind of clutch is this?

2. Can this clutch be called a positive drive type?

Explain.

3. Without disturbing the component representing the magnet, rotate the plastic disc through one cycle in the direction indicated by the arrow. Describe what happens in terms of which parts turn with the disc.

   Was the clutch engaged or disengaged?

4. Simulate energizing the magnet by depressing the armature, holding it down for only a few degrees while the disc is again rotated through a complete cycle. Describe what happens.

   Was the clutch engaged or disengaged this time?

5. What action causes the clutch to engage?

6. When a single pulse of voltage is applied to the magnet, for how many cycles does it affect the clutch?

   Return the mock-up to the instructor.

PART II

Obtain a counter unit from the instructor. Examine the unit and locate the following parts. Use the illustration in the text to help, if necessary. Put a check mark on the list after each item as the part is identified.

Drive gear,
Adding wheel,
Adding gear,
Adding wheel clutch gear,
Clutch engaging cam,
Clutch engaging cam arm and reset arm,
Carry cam,
Start magnet and armature,
Stop magnet and armature.

Before proceeding, make sure that the start and stop magnet armatures are in normal position. Consult the instructor if necessary.

1. What type of clutch is used in this unit?

2. Is this a positive drive or a friction type?

3. Is the clutch engaged or disengaged?

4. Are the clutch engaging cam arm and reset arm latched or unlatched?

5. Rotate the drive gear manually in a counterclockwise direction and describe what happens in terms of which parts rotate with the drive gear.

6. Manually depress the armature of the start magnet. What changes can be observed?

7. Manually rotate the drive gear again and describe the action in terms of which parts now rotate with the drive gear.

8. What finally caused the clutch to disengage?

9. Again depress the start magnet armature, observing that the clutch once more engages. Now depress the stop magnet armature. What happens?

10. Relatch the reset arm manually. What is the nature of the signal to be applied to these magnets?

    (a) Constant voltage.
    (b) Pulse.

11. Depress the stop magnet armature again. Rotate the drive gear until the reset arm relatches automatically. What caused the reset arm to relatch?

Return the counter unit to the instructor.

PART III

Obtain the punch feed and punch unit from the instructor. Examine it carefully and locate the following parts. As in Parts I and II, place a check mark after each item in the list after the part has been identified.

Punch magnets,
Punch magnet pull wires,
Eccentric shaft,
Punch bail,
Die.

Remove the die.

1. How many punch magnets are there?

2. The card feed will be

   (a) Digit by digit.
   (b) Column by column.

3. Remove the two screws that hold the bar covering the interposer assembly. Remove the bar and observe the manner in which magnet pull wires are connected. With the aid of illustrations in the text, sketch the assembly associated with one punch.

4. Connect the power supply (set at 0 volts) to the terminals of the magnet that operates the punch for card column # 1. Slowly increase the voltage until the armature pulls in.

   How was the associated interposer affected?

5. Manually turn the crank through one revolution of the eccentric shaft, observing the underside of the punch section.

   Which punch emerges through the stripper?

6. Disconnect one power supply lead so that the magnet de-energizes. Be sure that the interposer returns to its normal position. Now simply touch the power supply lead to the terminal to which it was formerly connected, long enough so that the armature of the magnet operates. Again crank the shaft through one complete revolution and observe the punch.

   The nature of the signal applied to the punch magnets should be

   (a) A constant voltage.
   (b) A pulse.

7. What action, by way of the pull wire, restores the magnet armature to normal?

Cover the interposer assembly by replacing the bar and fastening it into position by its two screws. Return the unit to the instructor.

PART IV

Obtain a 602A storage unit from the instructor and examine it to locate the following parts. Check the items off on the list as they are identified on the unit.

Setup magnet and armature,
Setup ratchet,
Armature pawl,
Digit contact bars
Latch trip magnet,
Reset bail,
Operating cam.

Check to see that the contact plungers are all underneath the blank contact bar.

1. Turn the operating cam through one revolution.

   Is the latch trip magnet armature latched or unlatched?

2. Simulate energizing the latch trip magnet by depressing the armature. Caution: the reset bail operates with considerable force. Fingers should be held clear of moving parts to avoid injury.

   Describe what happens as the latch trip magnet energizes.

3. Check again to see that the contact plungers are all underneath the blank contact bar. Again rotate the operating cam through one revolution, this time depressing one or more of the setup magnet armatures before the revolution is completed.

   Describe the effect.

Return the setup ratchets to the restore position by tripping the latch trip magnet, and return the unit to the instructor.

Digital Computer Fundamentals. Sample Laboratory Assignment.

TRANSISTOR GATING CIRCUITS.

PURPOSE: To investigate the use of transistors in various types of gates.

Discussion:

Gating circuits used extensively in computer design and in the design of control circuits frequently employ transistor-resistor or transistor-diode combinations. Transistors in gate circuits can be connected in series, in parallel, or in series parallel, to provide a considerable variety of functions such as circuit triggering at predetermined intervals, level control, waveshape control, and others.

The overall category of gates includes the AND, the OR, and the inhibitor circuits. The NOT, or NEGATION Circuit, refers to arrangements which provide pulse phase inversion, resulting in NOT-AND (NAND), and NOT-OR (NOR) circuits. Circuits of the type under discussion have the ability to evaluate input conditions to provide a predetermined output and are frequently referred to as 'logic' -circuits.

An OR gate has more than one input, but only one output; it provides a prescribed output condition when one or another prescribed input condition exists. Figure 1 illustrates a simple method of obtaining OR and NOR functions. In both circuits shown, the high resistance of R_1 and R_2 isolates one input source from the other.

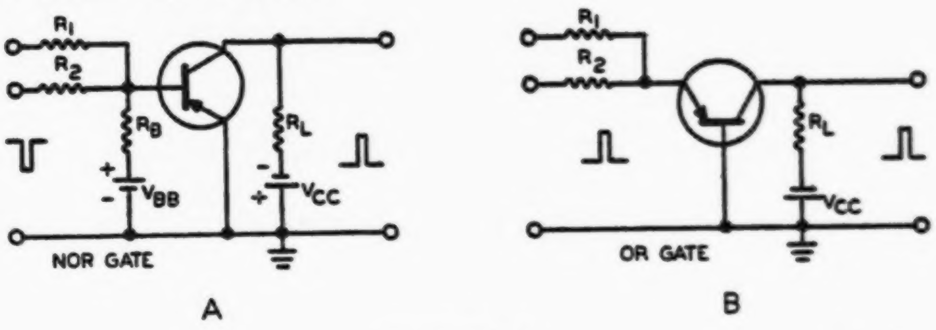


FIGURE 1

The simple arrangements of Figure 1 are inadequate where speed of operation is of great importance. Figure 2(a) shows an example of an emitter follower OR gate where the transistor outputs use a common load resistor. At quiescence, each transistor is held in cutoff by the voltage V_{BB}.

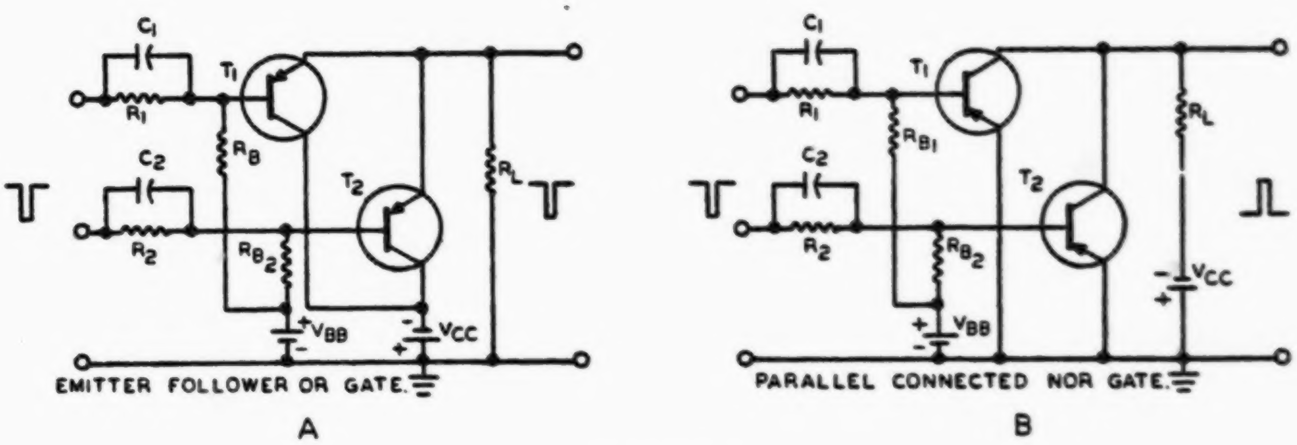


FIGURE 2

Figure 2a, the common collector, or emitter follower arrangement, has high input and low output impedances. Because of the high negative voltage feedback, the collector does not saturate, resulting in a more rapid response than that of other configurations.

In Figure 2b, with a negative pulse applied to the input of T_1, the voltage drop across R_L subtracts from V_{cc} and the output goes positive. If an additional pulse is applied to the input of T_2, the current flow through T_2 cannot be large because of the low collector voltage established by the conduction of T_1. Deep saturation of the collectors is avoided.

An additional circuit, utilizing diodes in combination with transistors is shown in Figure 3. The OR gate shown has the advantage over that of Figure 1 in that its response is more rapid. It uses fewer components to achieve similar results to that of Figure 2, but its response is not as good.

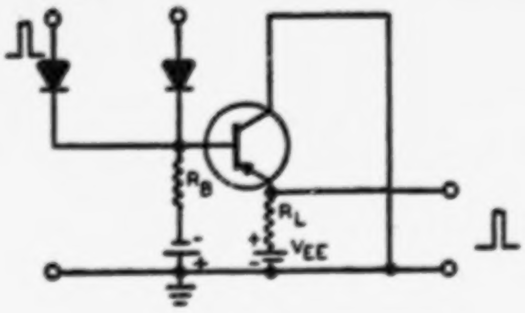


FIGURE 3

Operation of the AND gate differs from that of the OR gate in that the AND function requires that an output occur only when all inputs are applied simultaneously. Figure 4 illustrates the simplest method of obtaining the AND function, and by using a different circuit configuration, the negation, or NAND function.

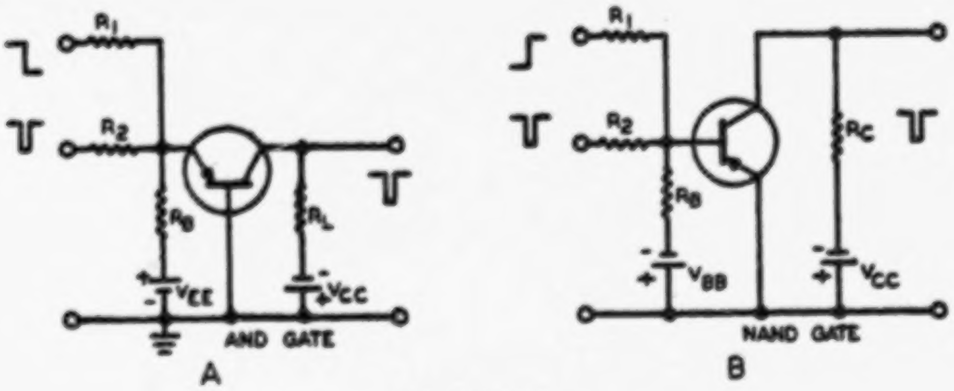
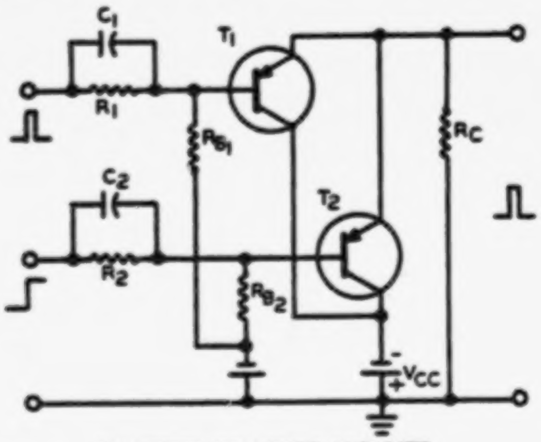


FIGURE 4

In both cases in Figure 4, the transistors are initially in saturation. In the case of the AND circuit of Figure 4a, both negative pulses are required to produce a negative pulse in the output.

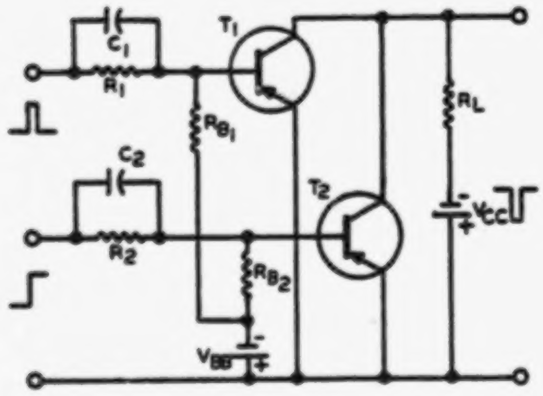
The NAND circuit in Figure 4b provides a negative output pulse when the inputs are both positive.

Figure 5 shows two-transistor arrangements for the AND and NAND functions for an improvement in speed of response.



EMMITTER FOLLOWER AND GATE.

A



PARALLEL CONNECTED NAND GATE.

B

FIGURE 5

The circuits in Figure 5 are very similar to those shown for OR and NOR gates, the main difference being the initial input bias conditions. Forward bias in both cases leaves the initial state of the transistors such that the input pulses must drive them into cutoff. The input signals must, of course, be positive.

Figure 6 illustrates the use of diodes in combination with transistors in an AND gate, with the same advantages and disadvantages as are obtained in the OR gate of similar configuration.

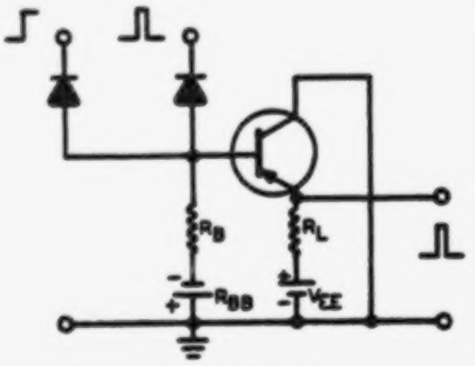
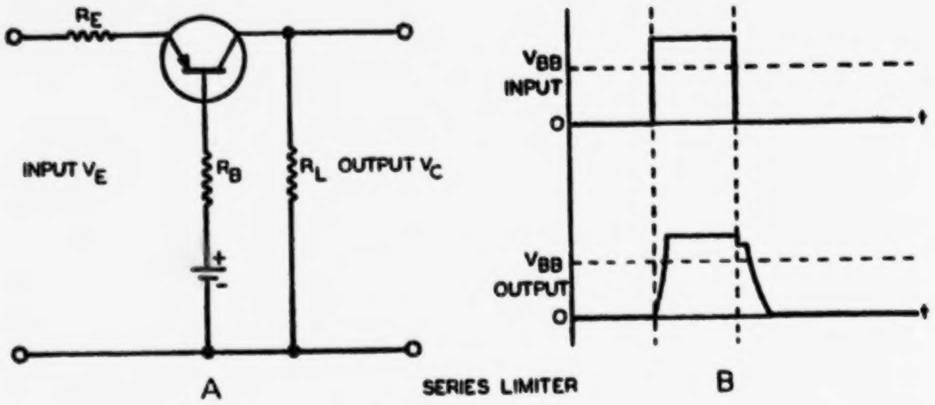
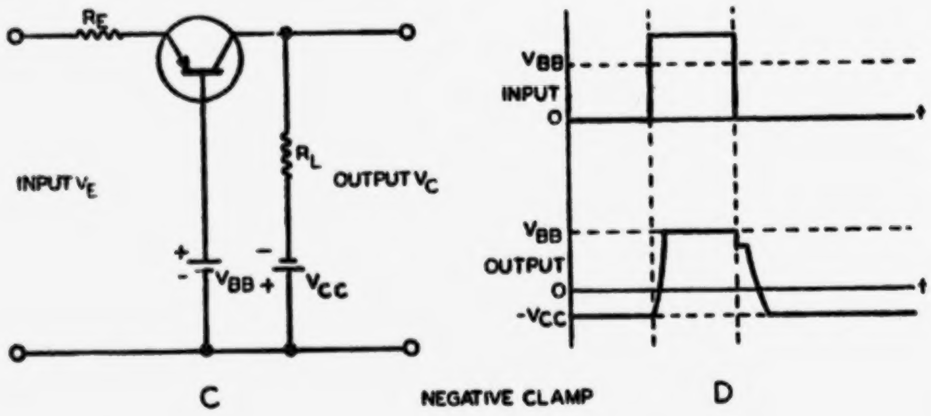


FIGURE 6

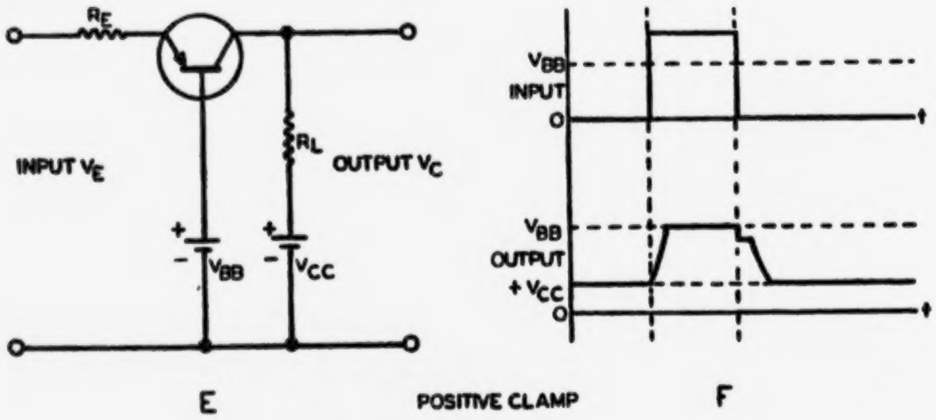
Series gating circuits are little more than series switches, although they can frequently be used as limiters (amplitude discriminators), clippers, and clampers. Figure 7 illustrates three series arrangements, using the common base configuration. The input and output waveforms shown should serve for explanatory purposes.


R_E
INPUT V_E
R_B
+
-
R_L
OUTPUT V_C
V_{BB}
INPUT
0
t
V_{BB}
OUTPUT
0
t
A
B

SERIES LIMITER


R_E
INPUT V_E
R_L
OUTPUT V_C
+
-
V_{BB}
-
+
V_{CC}
V_{BB}
INPUT
0
t
V_{BB}
OUTPUT
0
$-V_{CC}$
t
C
D

NEGATIVE CLAMP

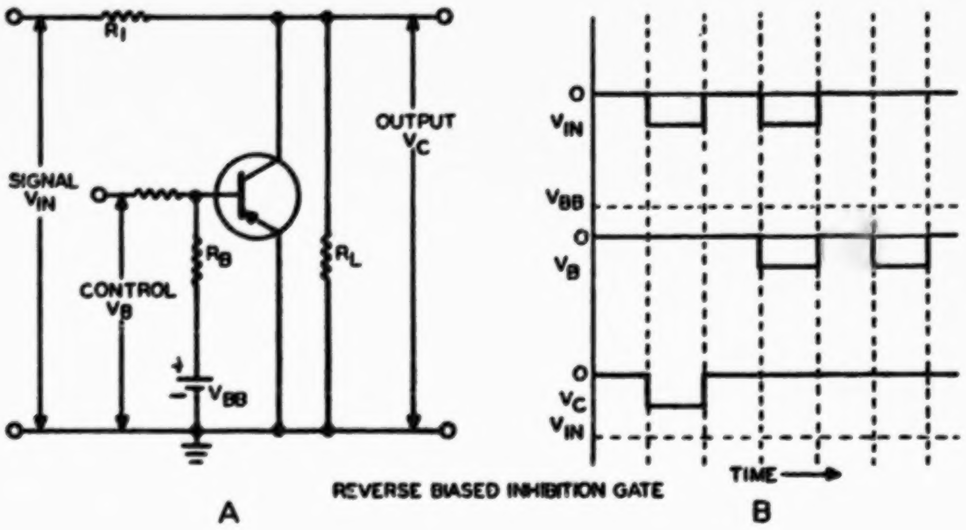

R_E
INPUT V_E
R_L
OUTPUT V_C
+
-
V_{BB}
+
-
V_{CC}
V_{BB}
INPUT
0
t
V_{BB}
OUTPUT
$+V_{CC}$
0
t
E
F

POSITIVE CLAMP

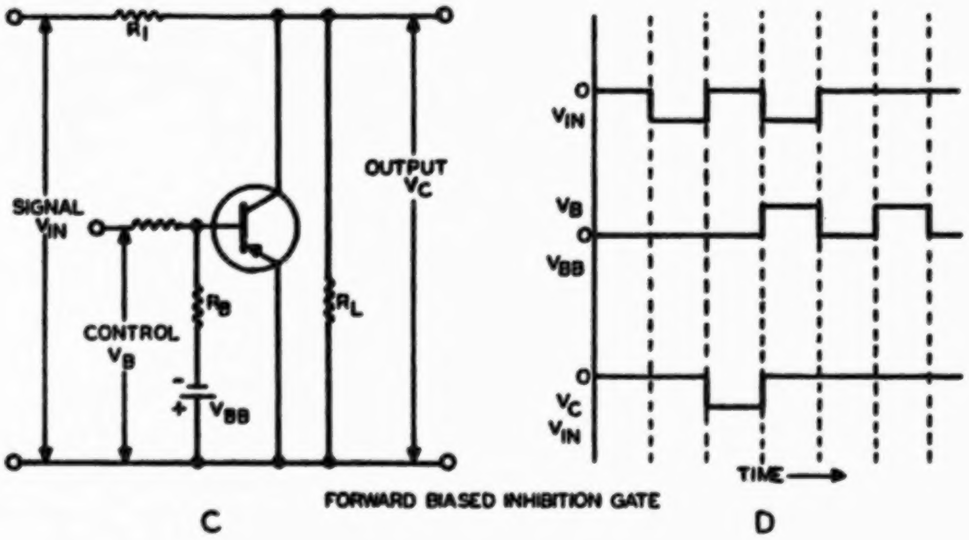
FIGURE 7

Shunt gating circuits are often called 'inhibition' gates. In this kind of arrangement, a control voltage is used to actuate the transistor that is to act as a switch. The signal voltage is either bypassed around the switch to the load (switch open), or shunted around the load (switch closed). Neither signal amplification nor phase inversion occurs, since the transistor is in parallel with the output and therefore affects the output pulses only indirectly. The common emitter configuration introduces a minimum of transient distortion.

Figure 8 shows two typical inhibition gates, with explanatory waveforms.



REVERSE BIASED INHIBITION GATE



FORWARD BIASED INHIBITION GATE

FIGURE 8

In Figure 8a, showing the reverse biased inhibitor gate, no collector voltage is applied; therefore, a signal voltage will appear across R_L only when an input signal (V_{in}) is applied, and the transistor remains non-conductive (open switch). When a control pulse is introduced at the control input (V_B), the emitter-base junction is forwarded biased, the switch closes and the signal is shunted around the load; that is, no signal appears at the output terminals. The control pulse must be large enough to drive the transistor into saturation. The other condition under which no output pulse appears occurs when a control pulse is applied but no signal pulse (V_{in}) is introduced, in which case there is no collector voltage.

The forward biased inhibitor gate in Figure 8c differs from the circuit in 8a in that the biasing voltage applied to the emitter-base junction leaves the transistor capable of conduction on the application of signal voltage V_{in}. An output pulse will appear across R_L whenever the control pulse and the signal input pulse coincide. With a signal input present but no control pulse, the transistor will conduct heavily (closed switch), and short out the load.

EQUIPMENT REQUIRED

Oscilloscope
Audio Signal Generator
Low Voltage DC Source
4 type 2N414 Transistors
Assorted Resistors and Capacitors

PROCEDURE

In the projects that follow, all circuits are to be considered and built on the basis of principles demonstrated in the previous laboratory job sheets dealing with transistor switching circuits.

1. (a) Build and test circuits to correspond to those in Figure 1 in the discussion.
   (b) Draw the diagrams and show input and output waveforms, indicating all pertinent values. Hint: For input signal sources, the overdriven amplifier, the audio signal generator, and/or a transistor astable multivibrator may be used. If a circuit is constructed to serve as a signal source, the diagram with all values must be shown.

2. (a) Build and test circuits corresponding to those in Figure 2 in the discussion.
   (b) Draw the diagrams and show input and output waveforms, indicating all pertinent values. Show diagrams with values of any circuits constructed to serve as signal sources.
   (c) Write a short discussion of how 1(a) and 2(a) compare.

3. (a) Build and test circuits corresponding to those in Figure 4 in the discussion.
   (b) Draw diagrams and show input and output waveforms, indicating all pertinent values. As in previous projects, show diagrams with values, of any circuits constructed to serve as signal sources.

4. (a) Build and test circuits corresponding to those in Figure 5 in the discussion.
   (b) Draw diagrams and show input and output waveforms, indicating all pertinent values. Show diagrams with values of any circuits constructed to serve as signal sources.
   (c) Write a short discussion of how 3(a) and 4(a) compare.

5. (a) Build and test circuits corresponding to those in Figure 8 in the discussion.
   (b) Draw diagrams and show input and output waveforms, including control pulses, and indicating all pertinent values. Show diagrams with values of any circuits constructed to serve as signal sources.

Sample Examination in Physics

1. An object undergoes harmonic motion. Its maximum speed occurs when its displacement from its equilibrium position is
   (a) zero
   (b) half its maximum value
   (c) a maximum
   (d) 3/4 its maximum value
   (e) none of these

2. A pure musical tone causes a thin wooden panel to vibrate. This is an example of
   (a) resonance
   (b) interference
   (c) an overtone
   (d) a harmonic
   (e) none of these

3. The higher the frequency of a wave
   (a) the shorter its wavelength
   (b) the larger its wavelength
   (c) the higher the period
   (d) the higher the velocity in the same medium
   (e) none of these

4. Sound waves are
   (a) longitudinal
   (b) transverse
   (c) partly longitudinal and partly transverse
   (d) electromagnetic
   (e) none of these

5. An object is placed 1 ft. in front of a concave mirror of focal length 2 ft. The image distance is
   (a) +9 in.
   (b) -9 in.
   (c) +24 in.
   (d) -24 in.
   (e) none of these

6. An object closer to a converging lens than its focal point always has an image that is
   (a) inverted
   (b) the same in size
   (c) virtual
   (d) smaller in size
   (e) none of these

7. Two tuning forks of frequencies 310 and 316 cycles/sec. vibrate simultaneously. The resulting number of beats per second is
   (a) 0
   (b) 6
   (c) 313
   (d) 626
   (e) None of these

8. Oxygen boils at -183°C. This temperature is
(a) -215°F
(b) -297°F
(c) -329°F
(d) -361°F
(e) none of these

9. The quantity of heat required to change the temperature of a unit amount of a substance 1° is called its
(a) specific heat
(b) heat of fusion
(c) mechanical equivalent of heat
(d) heat of vaporization
(e) none of these

10. 10 kg. of ice at 0°C are added to 100 kg. of water at 50°C. The temperature of the resulting mixture is
(a) 20°C
(b) 38°C
(c) 10°C
(d) 40°C
(e) none of these

11. When a vapor condenses into liquid
(a) it absorbs heat
(b) it evolves heat
(c) its temperature always rises
(d) its temperature always drops
(e) none of these

12. A 60 kg. woman eats a banana whose energy content is 100 Kcal. If this energy were used to raise her from the ground, her approximate height would be
(a) 3 m
(b) 30 m
(c) 300 m
(d) 0.3 m
(e) none of these

13. If a heat engine exhausting heat at 140°C is to have an efficiency of 0.3, it must take in heat at
(a) 200°C
(b) 317°C
(c) 400°C
(d) 600°C
(e) none of these

14. The image formed by a concave mirror is larger than the object
(a) when p is less than 2f
(b) for no values of p
(c) when p is more than 2f
(d) for all values of p
(e) none of these

15. When white light is refracted, the compenent colors tend to separate because
    - (a) the shorter wavelengths are bent more than longer wavelengths
    - (b) red is bent more than green
    - (c) the waves are longitudinal
    - (d) light cannot travel in glass
    - (e) none of these

16. When both sides of the paper of a grease spot photometer are equally illuminated, the intensities of the two light sources are
    - (a) directly proportional to their distances from the paper
    - (b) inversely proportional to their distances from the paper
    - (c) directly proportional to the squares of their distances from the paper
    - (d) inversely proportional to the square of their distances from the paper
    - (e) none of these

17. The image formed by a convex mirror is
    - (a) larger than the object, real and upright
    - (b) larger than the object, virtual and inverted
    - (c) smaller than the object, virtual and inverted
    - (d) smaller than one object, virtual and upright
    - (e) none of these

18. An object is placed 5.0 in. in front of a spherical mirror producing an inverted image one-third the size of the object. Compute the focal length of the mirror.
    - (a) 1.25 in.
    - (b) -5.0 in.
    - (c) -2.5 in.
    - (d) +2.5 in.
    - (e) none of these

19. The speed of light in a certain transparent medium is 2/5 the speed of light in air. The index of refraction of this substance is
    - (a) 0.5
    - (b) 2.5
    - (c) 1.5
    - (d) 1.0
    - (e) none of these

20. A film 3 cm wide is placed 10 cm from the lens of a projector. As a result a sharp image is produced 200 cm from the lens. The width of the image is
    - (a) 60 cm
    - (b) 10 cm
    - (c) 100 cm
    - (d) 50 cm
    - (e) none of these

21. A lens of focal length 20 cm has one plain side and one curved side. The radius of curvature is 10 cm. Find the refractive index.
(a) 1.43
(b) 1.50
(c) 1.40
(d) 1.61
(e) none of these

22. A point light source is located 5 cm from a converging lens. Find the power of the lens necessary to produce a parallel beam of light.
(a) 20
(b) 10
(c) 5
(d) 15
(e) none of these

23. A metal rod 87.000 cm long increases in length 0.129 cm when heated from 21^{o}C to 99^{o}C. The coefficient of linear expansion is

(a) $1.0 \times 10^{-5}/C^{o}$

(b) $1.9 \times 10^{-5}/C^{o}$

(c) $3.2 \times 10^{-5}/C^{o}$

(d) $5.7 \times 10^{-5}/C^{o}$

(e) none of these

24. If 200 cm^3 of a gas at 20^{o}C is heated to 80^{o}C at constant pressure, its volume becomes
(a) 213 cm^3
(b) 221 cm^3
(c) 233 cm^3
(d) 241 cm^3
(e) none of these

25. The process by which ice melts underneath the blade of an ice skate and then refreezes is called
(a) regelation
(b) critical pressure
(c) insulation
(d) crystallization
(e) none of these

26. How many grams of steam at 100°C are required to raise the temperature of 2.0×10^3 grams of water from 0°C to 80°C if only the steam phase is considered?
    - (a) 5.8×10^2 g
    - (b) 1.4×10^2 g
    - (c) 2.9×10^2 g
    - (d) 7.2×10^2 g
    - (e) none of these

27. The Carnot cycle operates
    - (a) only through two isothermal changes
    - (b) through one adiabatic change
    - (c) through adiabatic and isothermal changes
    - (d) only through one isothermal change
    - (e) none of these

28. A galilean telescope is to be designed to have an angular magnification of 30. The length of the telescope is 20 cm. Find the focal length of the objective.
    - (a) 10 cm
    - (b) -30 cm
    - (c) 20.6 cm
    - (d) -20.9 cm
    - (e) none of these

29. Which of the following statements are true?
    - (a) There is no difference between light and sound waves except frequency.
    - (b) Radio waves are like light waves except for frequency.
    - (c) Light is of longer wavelength than radio waves.
    - (d) Light must have a medium in which to travel.
    - (e) none of these

30. Total internal reflection can occur when light passes from one medium to another
    - (a) which has a lower index of refraction
    - (b) which has a higher index of refraction
    - (c) which has the same index of refraction
    - (d) at less than the critical angel
    - (e) none of these

Sample Examination in Digital Computer Fundamentals

1. Set up a truth table for a full adder.

2. (a) From the table developed in Question #1, derive the full adder logic equations.

   (b) Draw the full adder logical diagram from equations derived in 2(a).

3. (a) Draw a diagram to illustrate the operation of a serial full adder.

   (b) Draw a diagram to illustrate the operation of a parallel full adder.

4. (a) Give one important advantage of serial over parallel addition.

5. A parallel up counter is to be modified to reset at a count of 22.

   (a) Draw a logical diagram representing the basic counter.

   (b) Prepare a truth table for the basic counter.

   (c) Prepare a truth table for the modified counter.

   (d) Write the logical equations for the necessary modifications.

   (e) Using the equations developed, draw a logical diagram of the modified counter.

   (f) Prepare a timing chart for the modified counter.

Sample Examination in Mechanisms

1. Clutches may be classified into the following catagories:

   a) Positive Engagement
   b) Friction
   c) Magnetic Particle
   d) Magnetic (Hysteresis & Eddy Current)
   e) Overrunning (one way)

   For each catagory, make a sketch of the BASIC elements and BRIEFLY describe the operation of the clutch.

2. How may a purely mechanical clutch be converted to an electromechanical clutch? Use sketches.

3. Taking into consideration the primary uses of the clutches in question #1, indicate into which area(s) listed below they may best fit.

   a) Zero Slip
   b) Intermittent Slip
   c) Continuous Slip (drag)

4. For the following general applications, indicate:

   a) into which area (Question #3) the clutch best fits;
   b) which type of clutch (Question #1) is most suitable; and
   c) the reason for your choice.

      1. Coupling & uncoupling
      2. Transmitting running torque
      3. Controlled acceleration
      4. Speed changing
      5. Reversing
      6. Indexing
      7. Tensioning
      8. Positioning
      9. Torque limiting

5. The selection of a clutch or a brake is greatly effected by Inertia. What are the basic characteristics which effect Inertia?

6. How may a clutch be used as a brake?
   Use sketches if necessary.

7. A magnetic clutch generates heat when the current is applied. How would you design a magnetic clutch if the engaged cycle time were greater than the disengaged cycle time?

8. What type of clutch (basic) would you use in the following machines? Explain.

   a) Printing press
   b) Automatic screwdriver
   c) Numerical control machines
   d) Recording instrument

9. What are the BASIC elements of almost all feeding mechanisms and devices? Use sketches if necessary.

10. What are the primary things that a designer would have to know before proceeding to design a feeding mechanism or device?
    You may use an example in answering the question.

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- Functional Units
- 1403 Printer
- 1402 Card Read Punch
- 519 Reproducer Punch
- 1311 Disk Storage Drive

Manual of Instruction: 26 Keypunch, IBM Form #223-8319-9.
Manual of Instruction: 85 Collator, IBM Form #231-0001.
Reference Manual: 85 Collator, IBM Form #A24-1005-2.
Manual of Instruction: 519 Document, Originating Machine, IBM Form #225-6320-1.
Reference Manual: 519 Document, Originating Machine, IBM Form A24-1017-1.
System Operation Reference Manual, 1401 DPS, IBM Form #A24-3067-1.
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IBM Systems Reference Library, Disk Storage Input-Output Instructions, Form #A24-3070-2.
IBM Systems Reference Library, System Operation Reference Manual: 1401, Form #A24-3067.

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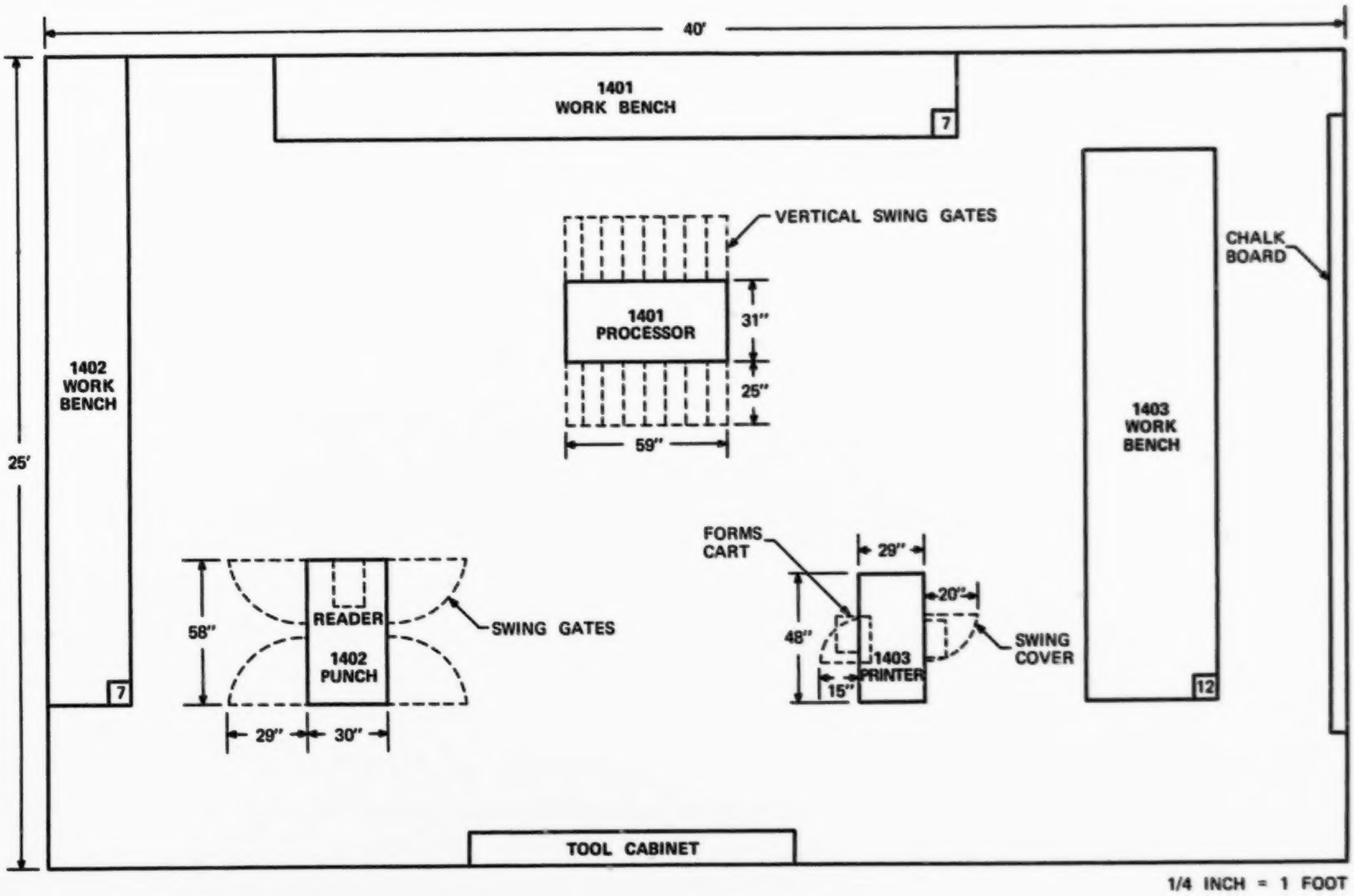
List of Equipment needed in Laboratory

1. Pic Kits - listed with Mechanisms
2. Linkage kits - listed with Mechanisms
3. Oscilliscope - 564 storage - Techtronix
4. Digital Logic Lab - Digital Equipment Corp.
5. DC Power Supply - 6291A - Hewlett Packard
6. Pulse Generator - 214A - Hewlett Packard
7. Strobotac - 1531 - General Radio
8. Paper Tape Punch - Surplus
9. Tape Recorder - Surplus
10. High Speed Printer - Potter Instruments - Surplus
11. Loose Paper Feed - Xerox - Surplus
12. IBM Sub-assemblies (as supplied to Consortium)
13. IBM Mock-ups (as supplied to Consortium)
14. IBM Dynamic Timers (as supplied to Consortium)
15. 1401 Computer (as supplied to Consortium)
16. Benches with power supplies
17. Light switch - Fibre Optics - Bausch and Lomb
18. Relays - various types
19. Clutches - various types
20. VOM - Simpson
21. Core Storage Units
22. Magnetic Drum - Servo Systems Co.
23. Motors - various types
24. Remington Rand Cash Register Keyboard - Surplus
25. Remington Rand Calculator - Surplus
26. 514 Punch Feed Assembly #606767
27. Unit Record Simulator, 514 Brush block & holder #178777, 134448
28. 514/519 Punch Assembly #606745
29. 514 Punch Mech. mock-up
30. 1402 Punch Model mock-up
31. Friction Clutch Assembly #310391 & Hub #31039
32. #528 Two-Speed Drive
33. Helical Spring Clutch Mock-up
34. Eject Clutch #237830
35. Magnetic Clutch Assembly #228981
36. 924 Ratchet Assembly #310372
37. Relay "Permissive Make" #344600
38. Unit Record Simulator CBS #255970, 205751, 216890
39. 602A Storage Unit
40. 085 Selector Unit #219775, 219665
41. 085 Selector mock-up
42. Data Flow mock-up 1401
43. 403 Counters #123430
44. #230637, 210204, 237405, 257205
45. 403 & 407 Print Mech. Mock-ups
46. Wire Printing Text/Reference
47. Preventive Maintenance Text/Reference
48. Disk, drum and ink equipment
49. 1401 Tape Deck
50. 1403 Chain mock-up

SUGGESTED COMPUTER LABORATORY LAYOUT


40'
25'
1401
WORK BENCH
7
1402
WORK
BENCH
7
VERTICAL SWING GATES
1401
PROCESSOR
31"
25"
59"
CHALK
BOARD
1403
WORK
BENCH
12
FORMS
CART
29"
20"
48"
15"
1403
PRINTER
SWING
COVER
58"
READER
1402
PUNCH
SWING GATES
29"
30"
TOOL CABINET
1/4 INCH = 1 FOOT